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Geneva Report: Inflation and Relative Prices*

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Abstract

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Summary of the findings

Chapter 1:

- The large surge in inflation owes to an exceptional combination of shocks, starting with the pandemic and followed by an extraordinary increase in energy prices, comparable in scale to that seen in the 70s and 80s.
- Central banks have tightened monetary policy sharply.
- Inflation expectations have remained anchored in the EA and US economies.

There are, however, significant differences between the EA and the US:

- The energy shock caused a large fall in the terms of trade (ToT) of the EA, a net energy importer, and an improvement in those of the US, a net exporter.
- The ToT dynamics is reflected in patterns of demand, with EA consumption and investment falling significantly below pre-pandemic trends, while US consumption and investment quickly overtaking pre-pandemic trends; this suggests differences between demand- versus supply- driven inflation.
- Though inflation remains elevated, most components of US inflation appear to have peaked. EA inflation, which started later, has so far seen falls only in non-core components.

Chapter 2

A historical analysis based on structural VAR estimation shows that:

- The response of inflation and its components to a supply oil shock has a rich dynamic heterogeneity and persists until all sectors have adjusted. This is in contrast to the response to monetary policy shocks, which is relatively more uniform.
- The response of inflation to an oil shock in the EA has typically been more persistent than in the US.
- Consistently with VAR results, indicating a lagged response of core inflation to headline, a Granger causality test shows that we cannot reject the hypothesis that headline causes core, but not viceversa.

Chapter 3

- The main empirical developments are modelled in a stylized New-Keynesian framework, where energy affects some sectors (e.g. manufacturing) directly, while others (e.g. services) indirectly through the use of intermediate inputs.
- In response to an energy shock, inflation in the energy-intensive sectors responds quickly, while inflation in the other sectors responds weakly early on and builds up more gradually.
- Higher degrees of nominal rigidity (as in the EA) delay the initial response of inflation and reduce its peak, but prolong the time in which inflation deviates from target.
- The open-economy version of the model implies that an economy dependent on foreign energy, like the EA, would experience a larger drop in consumption and a slower recovery than an economy that is self sufficient (or exports energy), like the US.
- Nominal rigidities impair relative-price adjustments, generating less reallocation of production across sectors than in a setting with flexible prices. Accommodating some additional inflation can facilitate the relative-price adjustment and efficient resource reallocation across sectors. Reallocation benefits need to be balanced against the risk of de-anchoring of inflation expectations, which are outside the model.

Chapter 4

- Market-based measures of tightening, including output or recession risk and financial indicators for the US suggests a material tightening underway.
- Most market-based indicators of prices (e.g., commodities and freight) point to an easing in price pressures.
- A comprehensive analysis of medium-term measures of inflation confirms that expectations remain well anchored.
- Expectations of real interest rate have increased slightly at the end of the sample. This increase is to be attributed to an increase in risk premia explained by the real premium, rather than the inflation premium. The increase is in line with historical volatility.

Introduction

Following more than thirty years of being low and fairly stable, inflation has surged materially in advanced economies. Underlying this surge, there is an unprecedented concomitance of factors: the Covid-19 pandemic, with the associated supply-chain disruptions and pent-up demand built up during periods of mandated or voluntary social distancing; the large fiscal responses, particularly in the US economy, aimed at limiting output and job losses during the pandemic; and the extraordinary increases in energy and other commodity prices caused by the war in Ukraine. Central banks around the globe have responded with a sharp tightening of monetary policy over a short period of time. This report focuses on the experience of the EA and US economies, taking stock on what has happened and the challenges ahead.

Economists at central banks, academia and markets have argued at length about the extent to which inflation would be transitory and whether it was mainly driven by supply or by demand forces. There seemed to be very little agreement, however, on the meaning of "transitory" (e.g., few months, one or two years?) or the desirable length of time over which central banks should return inflation to target following these extraordinary events. To the extent supply forces play an important role as triggers of inflation, monetary policy faces a difficult trade-off, a situation where the so called "divine coincidence" - in which price stability and output (gap) stability coincide - does not hold. This is particularly true in the Euro area, which, as a net importer of energy, has faced a large negative terms of trade shock, and a consequent squeeze in real disposable incomes.

Both in the US and the Euro area, the supply-chain disruptions and demand changes induced by the pandemic and the extraordinary increase in the prices of energy and other commodities caused by the war, led to large changes in relative prices. These relative price changes are explained by the fact that by nature, the triggering shocks are highly uneven, as they hit different sectors with different intensity, (e.g. an energy price shock hits more directly transportation services than medical services); in addition, different sectors feature different degrees of wage and price rigidities. The combination of uneven shocks and price- and wage- rigidity, along with the structure of input-output linkages across sectors, meant that the triggering shocks inevitably led to a complex staggered dynamics of sectoral inflation, generating a drawn-out response of core inflation, rather than a one-off, sharp adjustment in core price levels. At the time of writing, core inflation in the Euro area had plateaued at a 5.7% rate in march 2023 but had probably peaked in the US where it was 6.6% in September 2022 and reached 5.6% in March.

Part of the current debate over elevated core inflation can be split into two broad interpretations:

one is that high core inflation is symptomatic of de-anchoring of inflation expectations and/or second-round effects involving a profit and wage spiral. The second interpretation sees elevated core inflation as a reflection of a natural relative-price adjustment, needed for the efficient resource reallocation in response to a shock that hits different sectors with different intensity; this adjustment process would fully unwind with the triggering shock, though in the presence of nominal rigidities and input-output linkages, it would take somewhat longer to wane than the underlying shock. While the lagged effects of the tightening in monetary policy already in train should exert increasing downward pressure on inflation, the first interpretation of elevated core inflation would call for relatively more tightening of monetary policy, to act against de-anchoring or wage-price inertia. In contrast, in the second case, tightening should be limited, as the relative price adjustment is needed to achieve allocative efficiency and the inflation it generates would dissipate on its own with the end (or reversal) of the underlying inflationary shock.

There are costs and risks in pursuing each of these different strategies. The costs of over-tightening are an unnecessarily negative impact on economic activity, along with inefficiencies from relative price distortions, and, equally important in light of central banks' remits, the likely undershooting of the inflation target further in the future. The adverse effects on economic activity are likely to be more consequential in the Euro area in particular, since private consumption and investment are still materially below their 2019 trends. On the other end of the argument, there is a risk of deanchoring inflation expectations stemming from a persistent period of inflation above target, which must be carefully weighed to avert a repetition of the inflationary experience from the seventies.

To contribute to the debate, the report's main focus is on the dynamics of sectoral inflation adjustment in response to different types of shocks. The reports starts with a characterisation of the recent rise (and fall) in energy prices and a description of inflation, the terms of trade and some key activity indicators, as well as the monetary policy response, in the Euro area and the US. After setting out the main economic developments in recent years, the report characterises the historical behaviour of sectoral price adjustments. It then proposes a stylized model to rationalize the empirical findings and discusses some policy implications.

The empirical evidence points to a high degree of heterogeneity in sectoral inflation in response to energy shocks both in the Euro area and in the US. The Euro area has typically experienced higher persistence of inflation in response to energy shocks than the US. The analysis also underscores a lower degree of inflation heterogeneity across sectors in response to a standard demand shock (proxied by a monetary policy shock) rather than an energy shock. These features are captured in a stylized two-sector New-Keynesian model with nominal rigidities, where energy directly affects the production of one sector, say manufacturing, while it affects the other only through the use of intermediate goods, say services. This implies that in response to an energy shock, inflation in the energy-intensive sector responds relatively quickly, while inflation in the other sector is weaker early on, but then builds up and produces a second wave of sectoral inflation. Given the uneven structure of the economy, an aggregate demand shock would also generates some heterogeneity in sectoral inflation, but in much smaller scale than an energy shock that is also uneven in nature. The model can also explain the more persistent inflation response to an energy shock in the Euro area relative to the US. This is because the model generates an inflation response that is initially smaller but more persistent in the presence of a higher degree of nominal rigidities, which would be a characteristic of the the Euro area (cite related work XXX). To capture the different patterns of terms of trade between the Euro area and the US, we also explore an open-economy version of the model and show that an economy that is more dependent on foreign energy, like the Euro area, experiences a larger drop in consumption, which is consistent with the slower recovery of households' consumption in the Euro area relative to the US in the recent period.

The model shows how underlying nominal rigidities prevent sectoral relative prices to adjust in response to an energy shock, generating less reallocation of production across sectors than in a setting with flexible prices. This implies that when an economy with nominal rigidities is hit by an uneven shock, it may be necessary to tolerate some inflation to facilitate the relative-prices adjustment and the efficient allocation of resources across sectors. This calls for a more accommodative monetary policy stance relative to a situation where the same level of inflation is generated by an even demand shock for which there is no need of reallocation. The benefits of somewhat higher inflation in response to an uneven shock to allow for relative price adjustments need to be balanced against the potential risks of de-anchoring of inflation expectations. While the risk of de-anchoring expectations is outside of the model, we turn to it in the empirical analysis.

As a first step to gauge deanchoring risks, the report studies the evidence on inflation expectations during the inflation increases and subsequent tightening of the late seventies and early eighties, and compares them with the recent period. Arguably, the stability of long-term inflation expectations we have observed in the recent past is a credibility bonus that central banks can exploit to communicate the rationale for taking a bit longer to return inflation to target, as relative prices adjust.

The report turns next to the market's views on inflation, as reflected in financial market indicators. It provides an analysis of market data to understand the degree of effective tightening already under way through indicators of recession risk and financial tightening. It then analyses a variety of inflation expectation data to assess the degree of anchoring and its evolution over time. Finally, it analyses bond yields to disentangle risk premia from inflation expectations.

The report is organised as follows.

Chapter 1 reviews the empirical evidence on Euro area (EA) and US inflation and real activity in recent years and puts it into historical context. Chapter 2 documents historical patterns of sectoral price adjustments based on structural VAR exercises and offers a narrative on inflation in the 1970s and 1980s. Chapter 3 describes the stylized New Keynesian two-sector model with energy and carries out various modeling exercises to provide intuition. Chapter 4 studies financial market data while the last section offers concluding remarks, highlighting the key takeaways of the analysis.

CHAPTER 1: The Evidence

The past three years have witnessed unprecedented changes in relative prices in the world economy. These relative price changes were triggered by two tail events: first, the Covid-19 pandemic and its aftermath, which caused a significant increase in global goods demand at a time of global supply-chain disruption, giving impetus to the early phase of global energy and commodity price increases; and second, the war in Ukraine, which led to an extraordinary step jump in the prices of energy and other commodities. While most countries saw a material surge in inflation, the economic impact of these relative price changes differed across economies.

1.1 Where do we come from and where are we now?

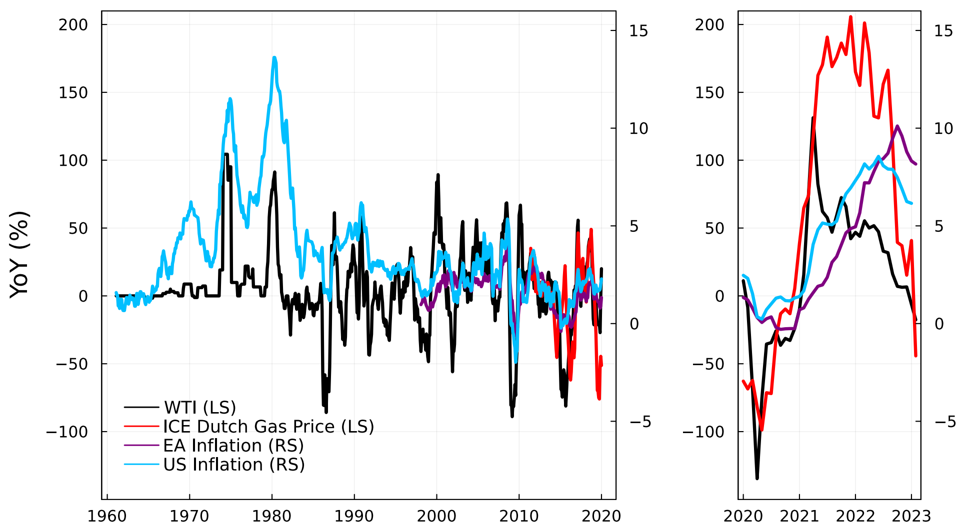
In this section we describe the main developments that marked the EA and US inflation and real-economy dynamics over this tumultuous period and put them into perspective.

A key driver of global inflation has been the increase in the prices of energy and other commodities.

Energy prices increased at an unprecedented scale, reaching peak in the summer of 2022.

Following sharp falls during the early phases of the Covid-19 pandemic, energy prices started increasing in the middle of 2021, largely reflecting the global demand rotation from services towards goods triggered by the pandemic. As the restrictions in gas supply to Europe caused by the war in Ukraine intensified, energy prices saw an extraordinary step-jump. This is illustrated in Figure 1, which plots the year-on-year growth of an index of global crude oil prices (World Texas Intermediate, WTI) and natural gas prices (Intercontinental Exchange Dutch gas price), along with annual EA and US inflation. The left-hand side plot shows the time series from 1960 through to 2020, while the right-hand side plot shows the series from 2020 to 2023. As the plots make clear, the recent trough-to-peak increases in energy prices are comparable, and indeed larger, than those experienced in the seventies and eighties. The figure highlights not only the extraordinary scale of the energy price increases, but also the pace at which energy prices picked up in a very short period of time.

Figure 1: Inflation and energy prices - The Euro area and the US



Source: Haver Analytics.

Increases in energy prices have multiple effects on inflation, which operate at different horizons.[1]. The first, direct effect, is reflected in petrol prices paid by consumers, as well as prices charged on household gas and electricity bills, which immediately push up on consumer price inflation.

There are also indirect supply-chain effects through firms' input costs, as the production of many goods and services requires a substantial amount of energy; moreover, even firms for which energy makes up only a small share of their total cost base can see an increase in prices as their intermediate inputs costs may also have increased, owing to rising energy prices. The pass-through of these indirect costs (or "first-round effects") is a key part of the adjustment in relative prices, and the persistence of this pass-through process may vary across sectors and countries.

The increase in energy prices can also lead to "second-round effects"; these refer to a variety of mechanisms that cause inertia from domestic wage and price setting, which, if persistent enough, could push up on inflation into the medium term. These are typically a product of various rigidities in real

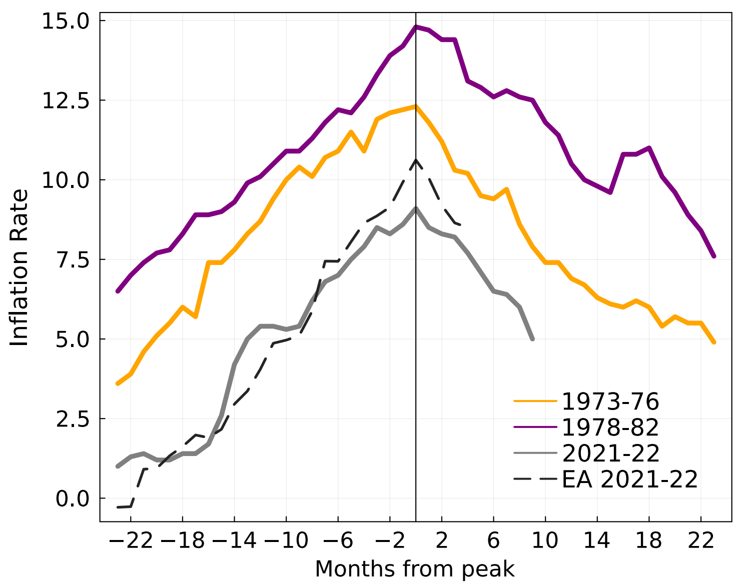
[1] See Tenreyro 2022

wages, profit margins and relative wages and prices. Similar channels could arise from increases in inflation expectations beyond the near term. (Near term inflation expectations naturally increase in response to an energy price increase, consistent with its direct and indirect effects; second-round effects or risks of deanchoring concern medium to long term inflation expectations.)

In addition to these first (direct or indirect) and second-round effects on domestic wage and price setting, there are also impacts on real incomes and real demand, which can push on medium-term inflation in different directions. A critical determinant of this real-income effect is whether the country is a net importer or exporter of energy, which is reflected in the behaviour of the economy's terms of trade.

Although the energy shock has been much larger this time, EA and US inflation have started to reverse much more quickly than US inflation did in the 70s and 80s, as illustrated in Figure 2.

Figure 2: Inflationary and disynflationary episodes



Source: Haver Analytics.

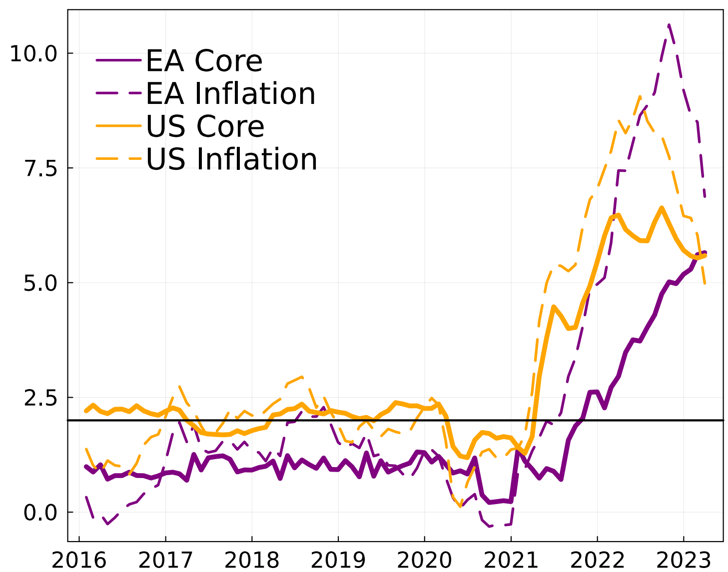
In what follows, we examine how the various channels through which energy prices transmit, along with other after-effects of the pandemic, impacted inflation and activity in the EA and US economies, and how monetary policy responded. We start with core inflation, which strips out the direct effects of energy prices.

Core and headline inflation picked up quickly above target in the US and, with a lag, in the EA.

This is illustrated in Figure 3, which shows CPI core, as well as headline inflation in both economies.

US core inflation responded quickly to the fast recovery following the reopening of economies after the period of mandated or voluntary social distancing. Although core inflation has been falling from its peak in 2022, it is still well above target. Similarly, US headline inflation has risen and started falling at a faster pace. The figure also shows the delayed response of core inflation in the EA economy. This reflects in part the EA's relatively weaker activity recovery post pandemic and, arguably, higher degrees of nominal rigidities in the EA, which tend to delay the indirect effects of the energy price increases on the costs and prices of other goods and services. EA headline inflation shows a steeper rise and a higher peak, as well as a steep fall (so far).

Figure 3: Core and Inflation Rates



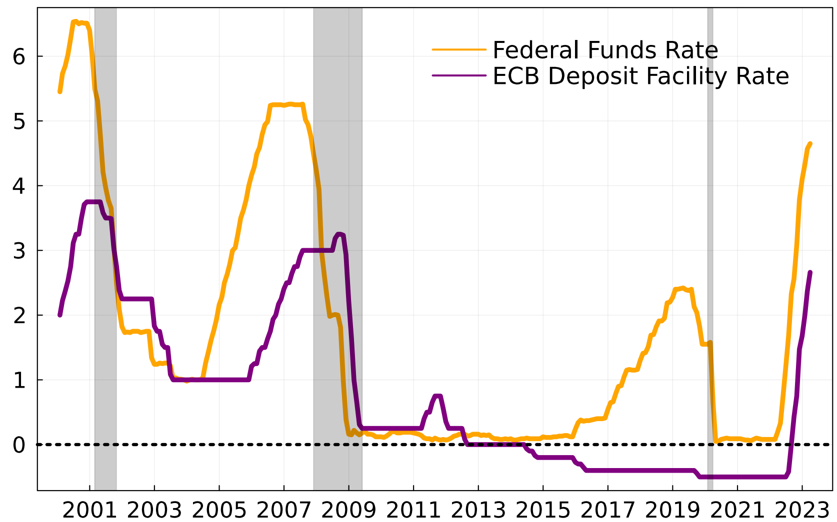
Source: Haver Analytics.

The pick up in inflation triggered a fast tightening of monetary policy.

Central banks increased policy rates at a rapid pace over 2022 and 2023.

The trajectory of policy rates is illustrated in Figure 4, which shows the ECB deposit facility rate and the Fed Funds Rate from 2001 through to the present. Both rates have increased sharply in 2022-23. The global synchronisation in tightening, all else equal, could accentuate the dampening effects of higher rates on the real economy and inflation via lending and cost-of-capital channels, while neutralising exchange-rate channels.

Figure 4: Policy Rates



Source: Haver Analytics.

Given the lags with which monetary policy affects the economy, however, inflation and activity outturns today only reflect a small proportion of the tightening already in train. Meanwhile, the various channels through which energy prices transmit continue to leave their mark in the real economy. We mentioned before that the real-income effects from energy prices differed depending on whether an economy was a net exporter or importer of energy. The contrast between the EA, a net importer of energy, and the US, a net exporter, is reflected in their terms of trade.

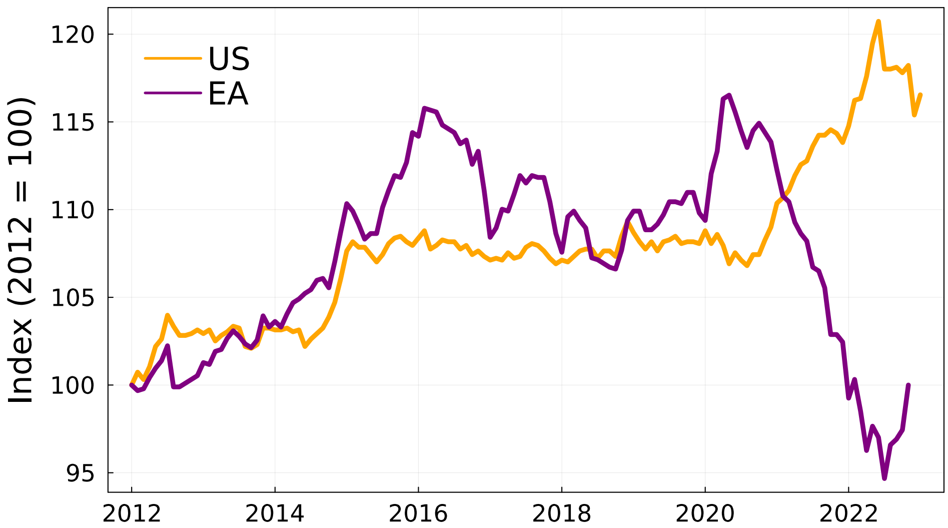
The EA experienced a precipitous fall in its terms of trade. In contrast, the US experienced a sharp increase.

This is illustrated in Figure 5, which shows that from the middle of 2021, a big gap opened up between the two economies' terms of trade (measured as the prices of goods and services exported by an economy, relative to the prices of those imported). The terms of trade encapsulate a key point in the debate over monetary policy: for the EA, the energy shock has been an adverse cost-push shock, while the opposite is true for the US, as a net energy exporter.

This terms-of-trade pattern most clearly illustrates the absence of a divine coincidence in the EA economy, as the negative terms of trade shock pushes up on near term inflation, while weighing on real incomes, and hence pushing down on demand and inflation in the medium term.

Reflecting the adverse terms of trade shock, activity responded differently in the two economies.

Figure 5: Terms of trade

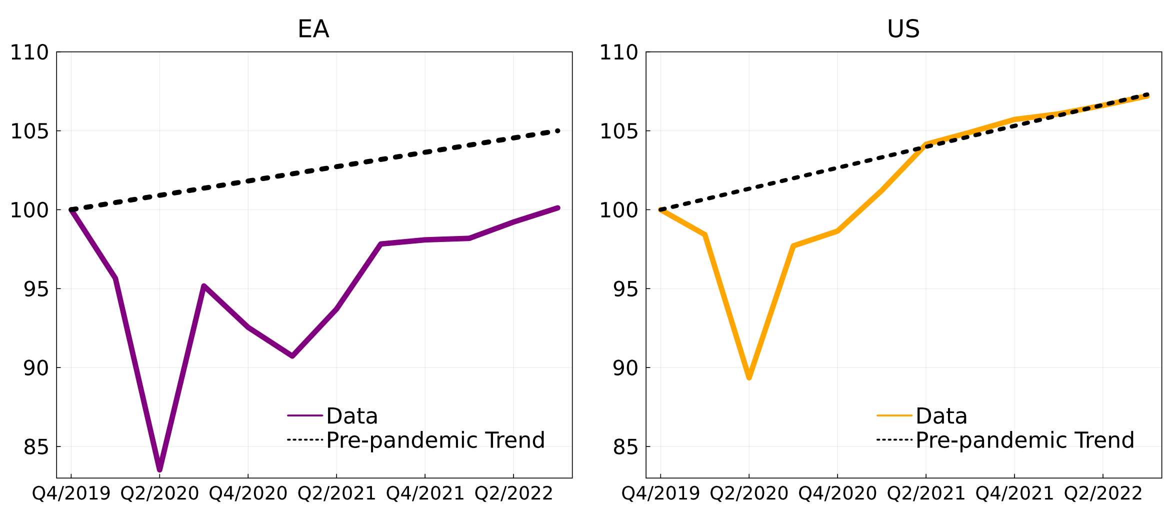


Source: Haver Analytics.

EA private-sector demand has fallen well below its pre-Covid trend, whereas US private-sector demand picked up quickly and has been running above its pre-Covid trend.

Starting with private-sector consumption, as illustrated in Figure 6, EA Consumption has been running significantly below its pre-Covid trend. Indeed, consumption only recently returned to its pre-Covid levels. In contrast, US consumption displayed a very quick recovery, reaching pre-Covid level in mid-2021 and starting to run above its pre-Covid trend by the middle of that year.

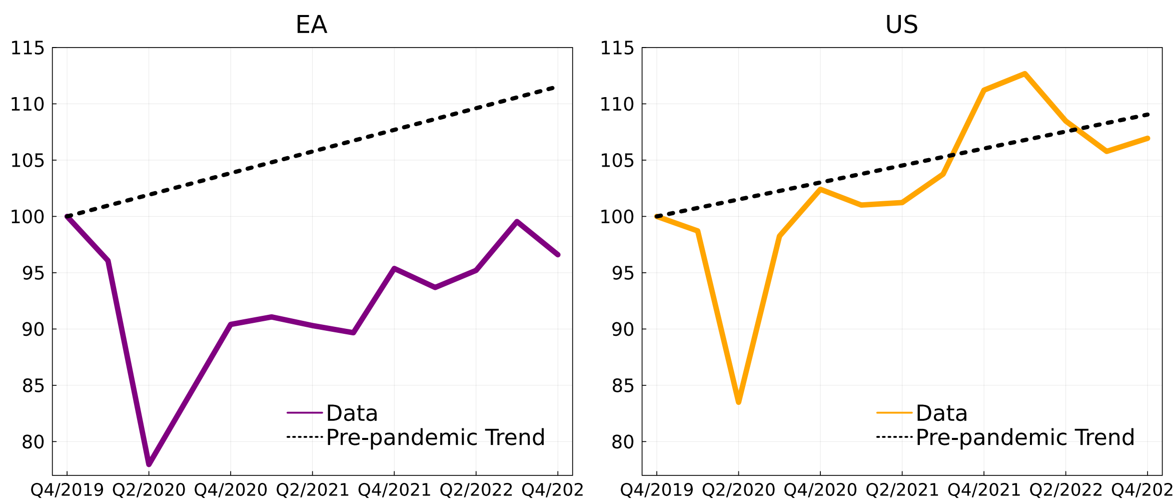
Figure 6: Private Consumption



Source: Haver Analytics. The pre-pandemic linear trend is computed on the sample Q1-2015:Q4-2019.

An even more striking pattern is displayed by Private Investment. Figure 7 shows that EA investment has been running well below its pre-Covid levels (and is materially below pre-Covid trend), whereas US investment overtook its pre-Covid level in 2020 and has been running well above its pre-Covid trends.

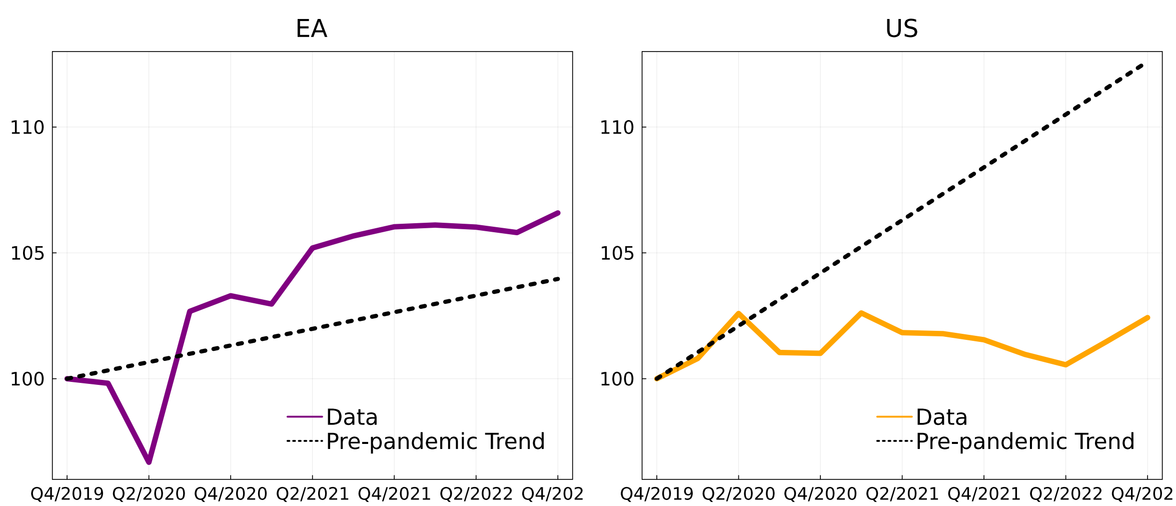
Figure 7: Investment



Source: Haver Analytics. The pre-pandemic linear trend is computed on the sample Q1-2015:Q4-2019.

Partially offsetting private demand, government consumption expenditures have been stronger in the EA than the US economy, as illustrated in Figure 8, which shows the US series hovering around pre-pandemic trend, while the EA increases above trend after an initial drop in 2020.

Figure 8: Government Consumption Expenditure

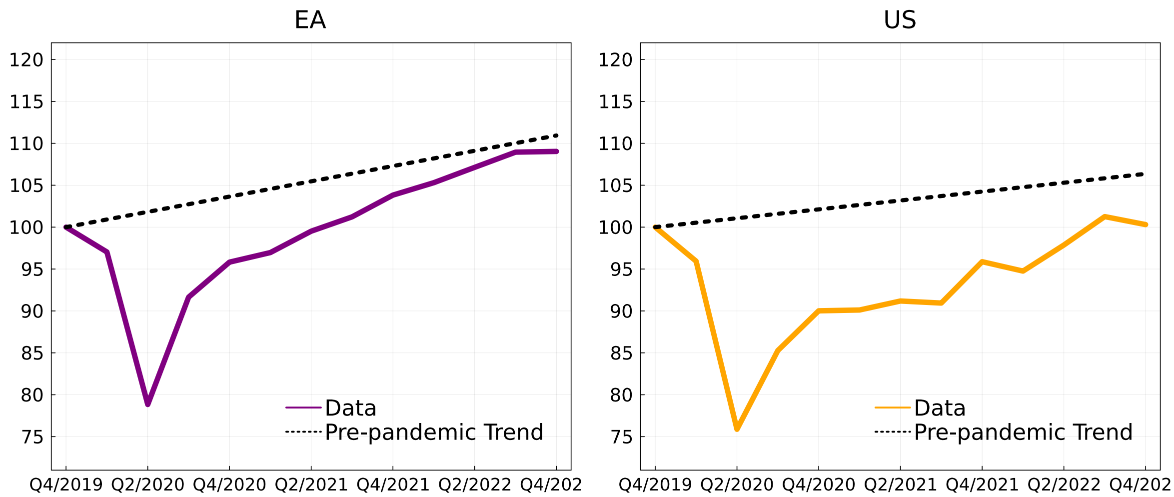


Source: Haver Analytics. The pre-pandemic linear trend is computed on the sample Q1-2015:Q4-2019.

The behaviour of exports and imports has also been different in the two economies as illustrated in

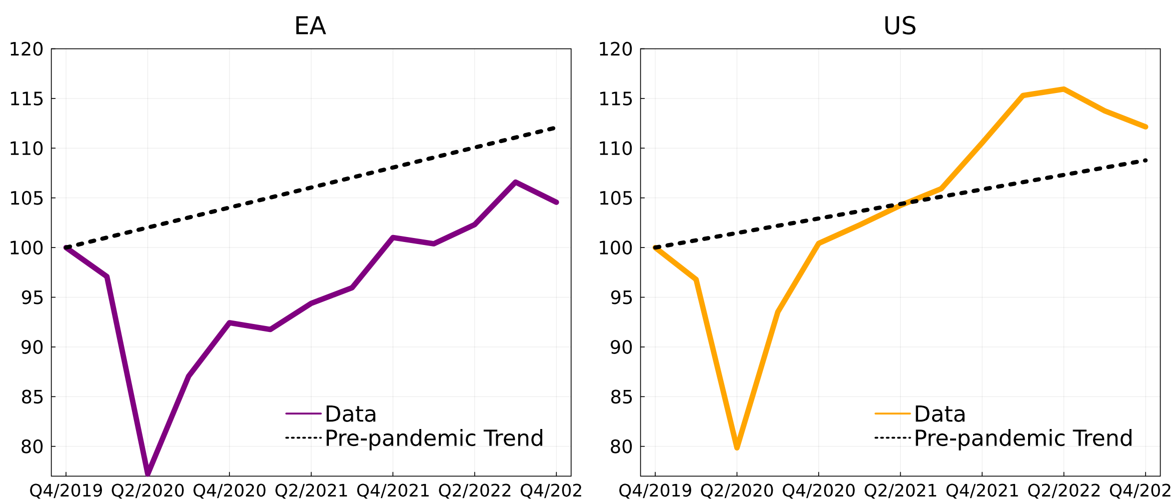
Figures 9 and 10. Both exports and imports have been well above trend in the US economy, with a net weakening in the balance of trade as imports increased more strongly than exports. In the EA, both exports and imports remain below pre-pandemic trends, but net exports have been strong, given the relative weakness in imports.

Figure 9: Export



Source: Haver Analytics. The pre-pandemic linear trend is computed on the sample Q1-2015:Q4-2019.

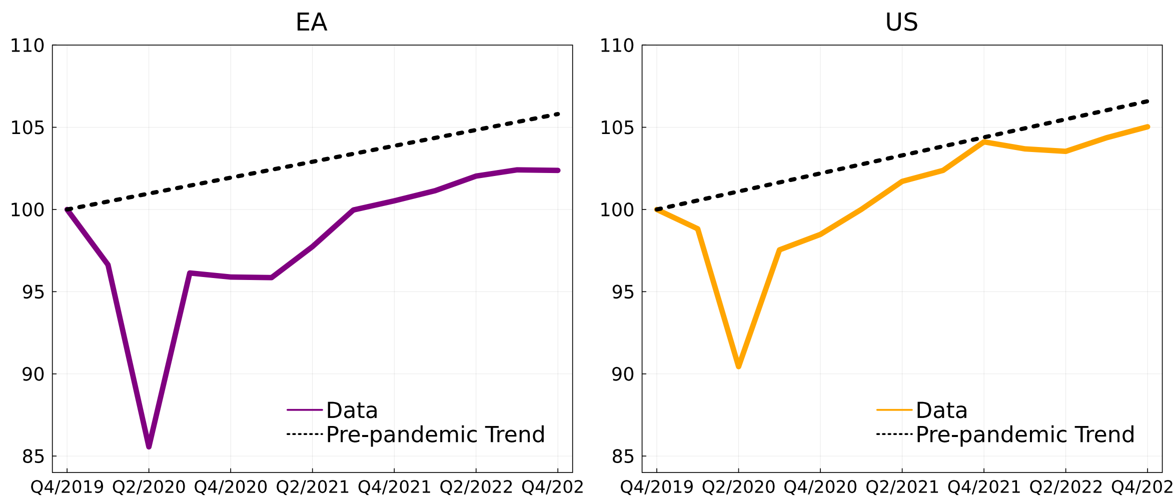
Figure 10: Import



Source: Haver Analytics. The pre-pandemic linear trend is computed on the sample Q1-2015:Q4-2019.

Aggregating over all components, real GDP, shown in Figure 11, has been markedly weaker in the EA economy, running consistently below trend. In the US, instead, real GDP reached its pre-pandemic level by the end of 2020 and started running above its pre-pandemic trend in the middle of 2021, starting a sharply steeper trend through the rest of the period.

Figure 11: Real GDP



Source: Haver Analytics. The pre-pandemic linear trend is computed on the sample Q1-2015:Q4-2019.

It is clear from the charts that demand has been significantly stronger in the US than in Euro area. To be sure, the trends showed in the figures cannot be interpreted as an estimate of potential; however, to argue that demand is a strong driver of inflation, one has to assume that weak GDP dynamics is driven by a collapse in potential output since the Ukraine war. Although we cannot rule out that possibility without a full analysis of output potential, it seems a priori a hard case to make.

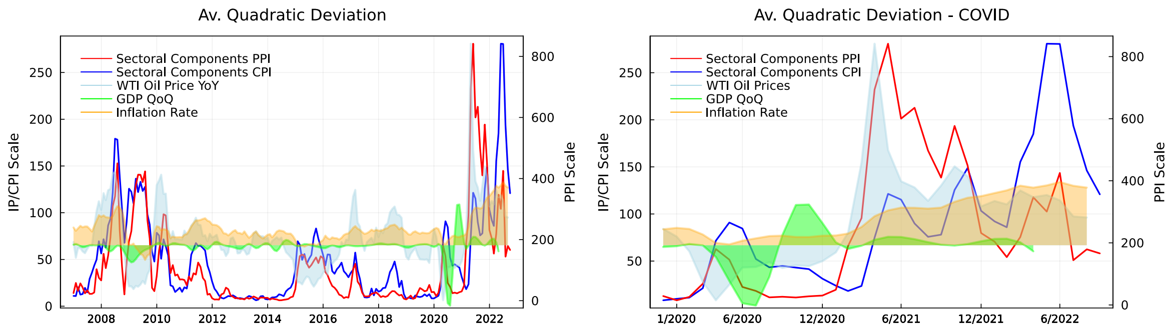
Aggregate figures of inflation and activity hide significant differences in price dynamics across sectors.

There has been significant heterogeneity in sectoral inflation.

This sectoral heterogeneity in inflation reflects the uneven nature of the underlying shock, which affected some sectors significantly more than others, and the staggering of relative price adjustments across different sectors. Figure 12 shows indicators of price dispersion for the US economy. Specifically, the red and blue lines are the average quadratic deviation of the disaggregated prices from headline producer price inflation (PPI) and CPI inflation, respectively. The light blue line is the year-on-year growth rate of WTI OIL prices, while the two shaded areas are real GDP growth (quarter-on-quarter) and year-on-year inflation rates. The plot on the right zooms in on the post-2019 period. As it is clear in the plots, the quadratic deviation of PPI inflation components increased first and that dispersion got subsequently reflected in the dispersion of CPI sectoral components.

The heterogeneity in price dynamics is also reflected in measures of inflation momentum in the various sectors, as illustrated in Figures 13 for the EA and 14 for the US economy. The momentum indicator

Figure 12: Sectoral inflation variability



Source: Haver Analytics.

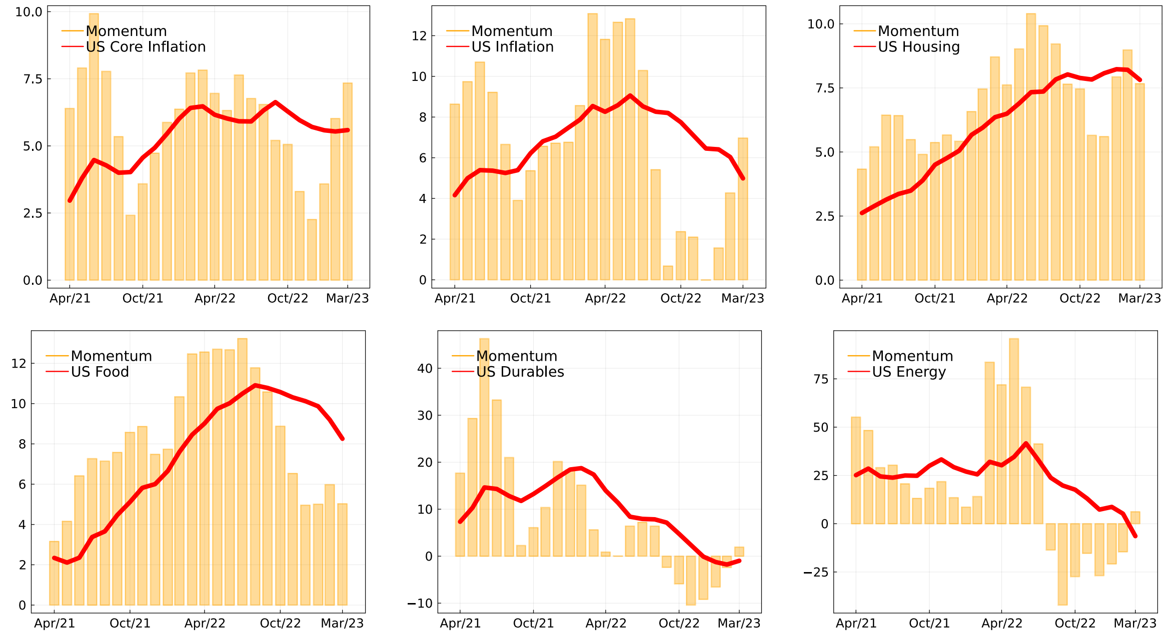
is constructed as the annualised three-month-on-three-month inflation rate, while the red line is just the year-on-year inflation measure.

The figures show that momentum of overall inflation has already peaked in both economies, but there are important differences across sectors as well as between the two economies. In the EA, while energy, goods and overall inflation have peaked, with momentum turning negative, food, housing and core inflation are still gaining momentum. In the US instead, energy, food, durable goods, and housing have all reached peak, with negative momentum in durables and energy, while core inflation seems to have stabilised at a high level at the end of the sample.

Figure 13: Inflation momentum - the Euro area

Source: Haver Analytics.

Figure 14: Inflation momentum - the US



Source: Haver Analytics.

1.2 Taking stock on where we are and where we might be heading

Following a year of fast and material monetary policy tightening in both the EA and the US economy, the questions are: where are we now? And where are we heading to? These questions are particularly relevant as the lagged effects of monetary policy tightening are yet to make their way through the economies.

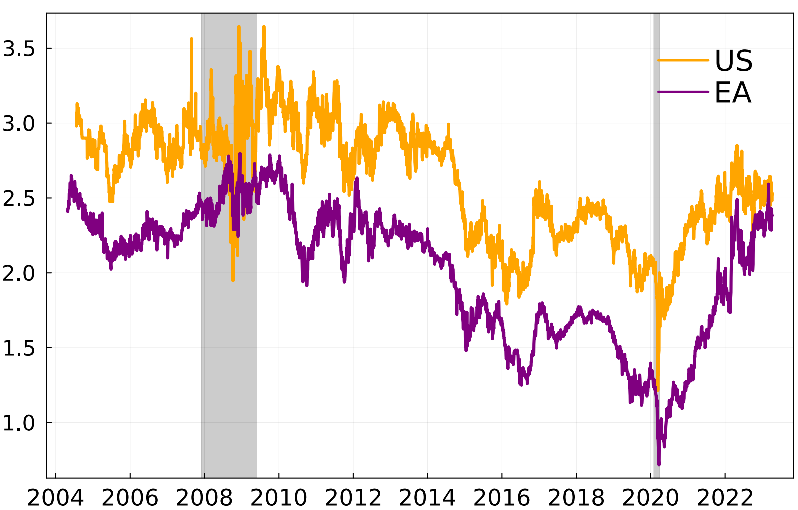
The prices of energy and other commodities have fallen significantly since their 2022 peaks. Moreover, indices of supply constraints have eased materially, with virtually all of them back to their pre-pandemic levels. We should hence expect many of the developments of the past three years to be put into reverse. But, critically, we should also assess the key risks that underpinned the monetary tightening, namely deanchoring of inflation expectations or price inertia, additional demand strength stemming from households' savings during the pandemic, and labour market tightness. We address each of these factors in turn, before concluding the chapter with a brief discussion of the expected impact of tighter financial conditions and efficiency considerations, two points that we address in detail in the next two chapters.

Measures of long-term inflation expectations remain well anchored.

In contrast to short-term inflation expectation measures, which naturally responded to the spike in supply constraints and the pick up in energy prices, long-term measures of inflation expectation remain well anchored in both the EA and US economies. Following a sharp fall at the outset of the pandemic, long-term measures of inflation expectations have now returned to target-consistent levels. This is illustrated in Figure 15, which shows the behaviour of inflation expectations implied by the 5-year-to-5-year inflation-linked swaps. Since 2022, these series have been oscillating around 2.5%. For the US, this is slightly higher than over the period 2015-2021 when inflation was below target, but lower than the average of the 2004-2014 decade. For the Euro area, this indicator is back to the level of 2012, after which inflation declined rapidly and persistently under-shot. Overall, financial-market implied measures of inflation expectations appear in line with target-consistent levels. We return to this point in Chapter 4, where we perform a deeper and broader analysis of inflation expectations.

Arguably, the stability of long-term inflation expectations reflects credibility in the monetary policy framework's ability to return inflation to target. This might prove to be an important difference from the experience in the seventies and eighties.

Figure 15: Inflation Linked SWAP 5Y5Y

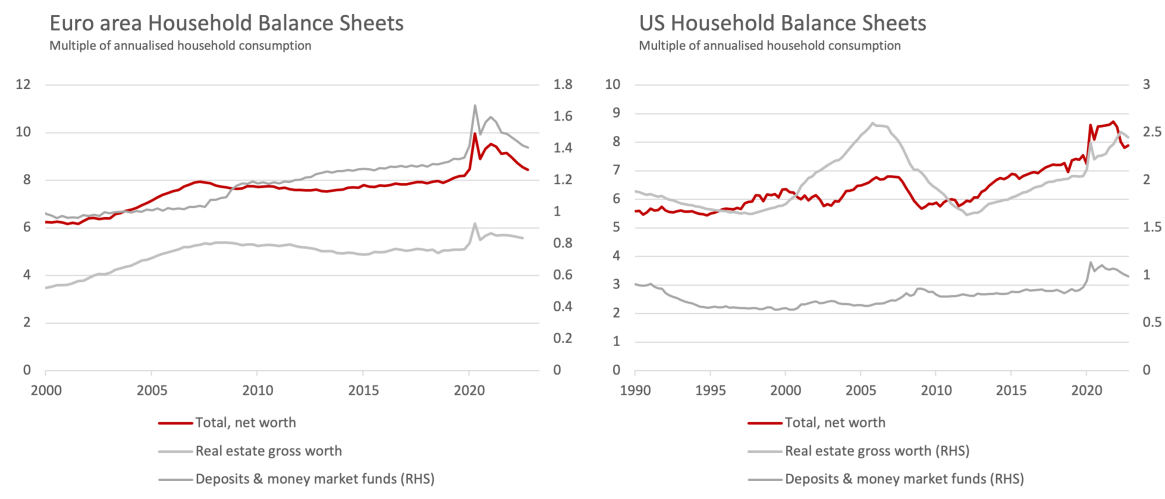


Source: Bloomberg

Household savings accumulated during the pandemic have been eroding.

Figure 16 displays EA and US households' total network, split into two components, i)real estate and ii) deposits plus money market funds, both expressed as a multiple of consumption. In both economies (though particularly in the US), total net worth over consumption jumped up in the early phase of the pandemic, owing to the negative impact of voluntary or mandated social distancing on aggregate consumption, together with the income support packages put in place by governments. This led to the expectation that demand might be also more resilient throughout the energy price crisis, as households not only had higher net worth but also stronger liquid buffers, typically thought to have a higher marginal propensity to consume than other, less liquid assets. However, most of those gains have now unwound to reach their pre-pandemic levels, suggesting savings may not provide support for consumption for much longer.

Figure 16: Household Balance Sheets



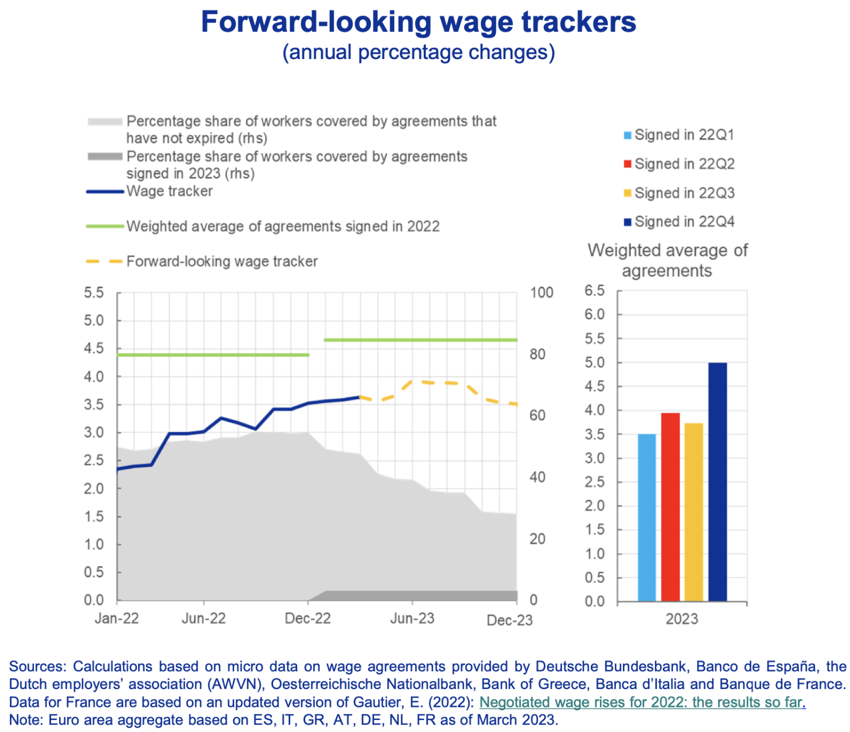
While unemployment is at record lows, real wage growth has been weak, with no evidence of explosive nominal spirals.

A key characteristic of the post-pandemic recovery has been the tightness of labor markets both in the EA and the US economy. This has been captured in various indicators of labour market quantities, including unemployment and vacancies. However, this tightness has not translated into higher real wages. Data on nominal wages and profits have not shown signs of potential wage-price spirals. Figure 17, taken from Lane (2023), shows a wage-tracker and implied expected wages for workers covered by wage agreements until the end of 2023 for the Euro area. As shown in the picture, nominal wage inflation has remained well below price inflation throughout this period.

Financial conditions have tightened materially.

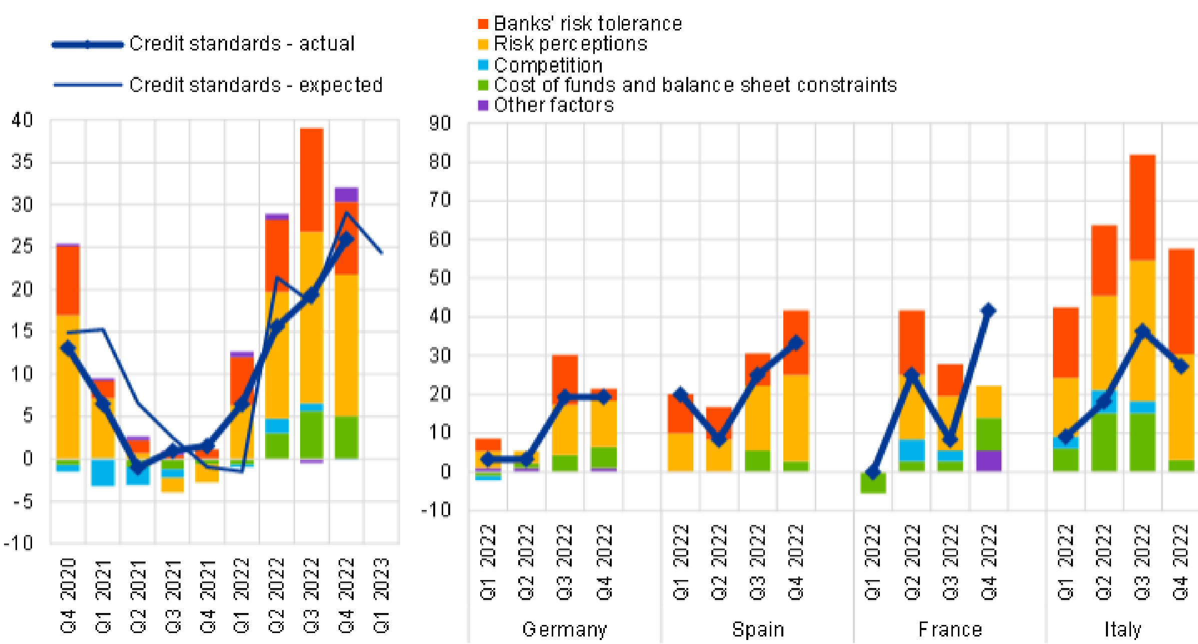
Indicators of financial condition have tightened materially. Figure 18 reports the findings from the ECB lending survey, which hints at a sharp tightening in the last quarter of 2022. Lending tightening, as revealed by the ECB lending survey, is known to be a leading indicator of a business contraction.

Figure 17



Source: Lane, 2023

Figure 18: Lending Survey



Source: Lane, 2023

We return to this point in Chapter 4, which offers a more thorough analysis of financial market indicators and the recent tightening in US financial conditions.

Where are we heading to? The initial shock to energy and other commodity prices is still being passed through via input-output linkages, given the structural lags in production (and costs' pass-through via inventories) and wage- and price-setting decisions. This relative price adjustment takes time, as we will see in the next Chapter, which examines the historical evidence. Meanwhile, the triggering shock has unwound materially, as energy and other commodity prices fell sharply from their 2002 peaks. This should cause an eventual end and possible reversal in the pass-through process, with a fall in inflationary pressures stemming from the shock's direct and indirect effects, as well as from any second-round effects. The momentum pictures show that the process is already in train in some sectors. The unwind of the cost-push shock should also support activity, all else equal. However, policy rates and overall financial conditions are significantly tighter than those prevailing in the pre-shock period.

Given the lagged effects with which financial conditions transmit to the real economy, most of the negative impact on activity from this tightening is still to come through. The lags in the transmission of monetary policy underscore the risks of over-tightening, which would push down inflation below target in the medium term and could cause material efficiency losses. The next chapter turns to one of one of the costs associated to over-tightening: economic losses from restricted reallocation.

CHAPTER 2: Empirical analysis of historical inflation dynamics

This Chapter starts by providing new analysis of the sectoral inflation response to oil supply shocks in both the US and the Euro area. It then focuses on the US case, for which we have better data and a longer sample, to compare sectoral inflation responses to an oil supply shock with those to a demand shock (proxied by monetary shocks).

The chapter then reports Granger-causality tests in-sample and out-of-sample for headline and core inflation in the Euro area. Finally, it turns to the lessons we can draw from history and discusses differences and similarities from previous episodes of high inflation.

2.1 Sectoral inflation in response to supply and demand shocks

In this section we first report results based on estimated structural Vector Auto Regression (VAR) to document the sectoral inflation response to oil supply shocks in the US and the euro area and differences between the response to oil and the response to a monetary shock. We have considered CPI inflation for the US and HICP for the Euro area.

In all specifications, data are monthly and sectoral inflation variables are in year-on-year rate of change. As for real variables, we have considered personal income and personal consumption expenditure also in year-on-year rate of change, industrial production in log levels while unemployment rate and capacity utilization are in levels.

The different exercises use different specifications owing to data availability constraint.

Impulse response functions are derived from partial identification of an oil supply shock and a monetary policy shock. Shocks are obtained using high frequency identification methods with external instruments. Box 2.1 describes the estimation method and the identification of both shocks.

2.1.1 The response of sectoral inflation to oil supply shocks in the US and the Euro area

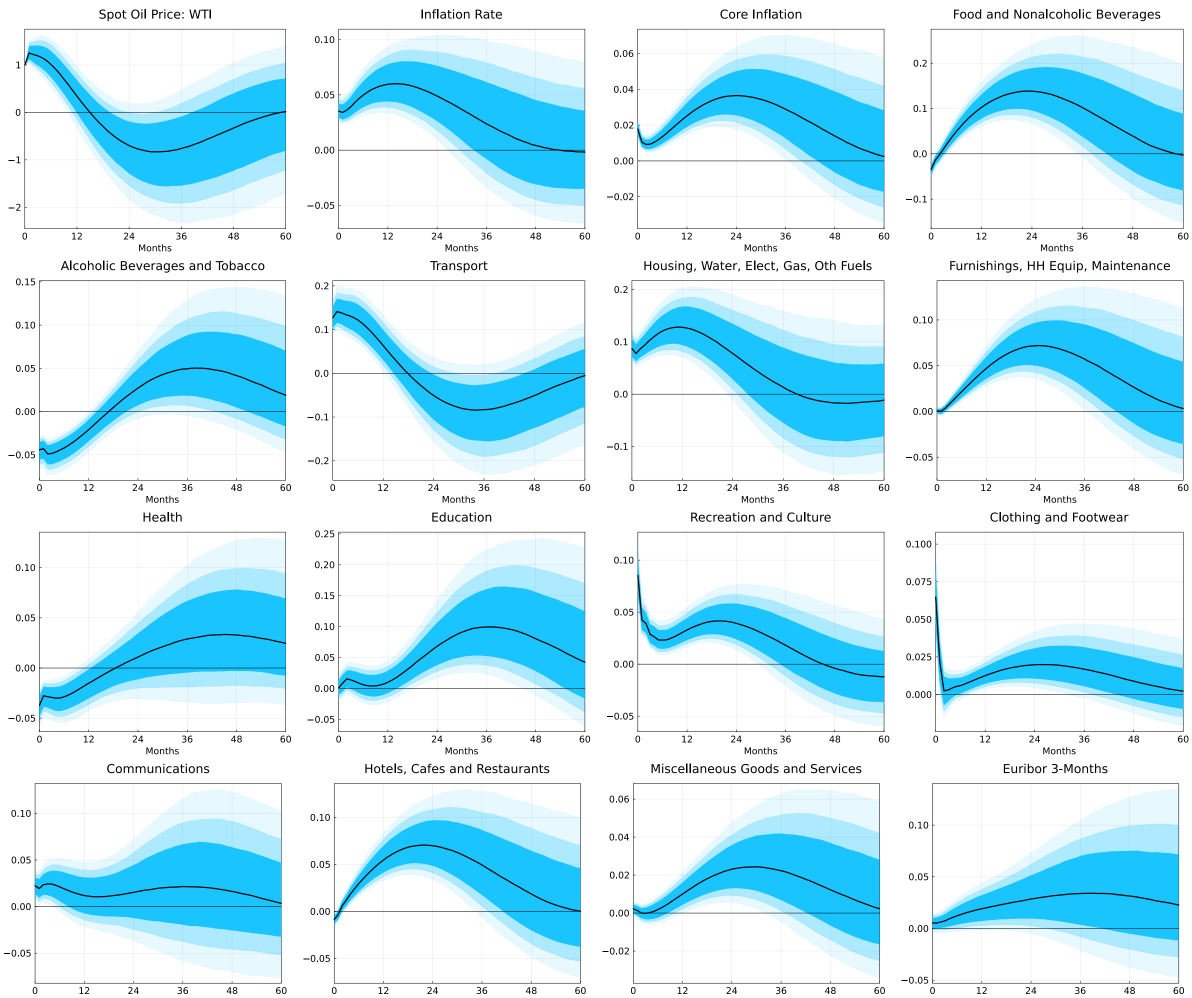
The sample considered is 1997:1 to 2022:12. We are reporting impulse responses to an oil supply shock which has been identified using Känzig 2021 data as instruments. Estimation and identification methods are described in Box 2.1.

Figure 19 reports results for inflation and components for the Euro area and Figure 20 does the same for the US. To interpret the size of the responses, note that the shock is a 1$ increase of the WTI price series. Therefore, if the value of the impulse response function for inflation at impact is 0.05 (as it is in the US case), this indicates that a 80 $ oil shock has an impact effect on inflation of 4% relative to the steady state. Variable specifications are not identical between the two jurisdictions because of differences in classification. In particular, the US specification includes real variables that are absent in EA VAR given lack of reliable data at the monthly level.

Let us start from the EA. Core inflation clearly lags headline and is more persistent. The shock is fully absorbed only after five years while the effect peaks after two years. If the present inflation episode corresponded to this historical norm and no other shocks were hitting the economy, we would expect that core would peak sometime at the end of 2023. The impact on food is large and slightly lagging that on core while transport has a similar dynamic shape as oil prices. The response of the broad category of housing and utility is less persistent than core but larger in size.

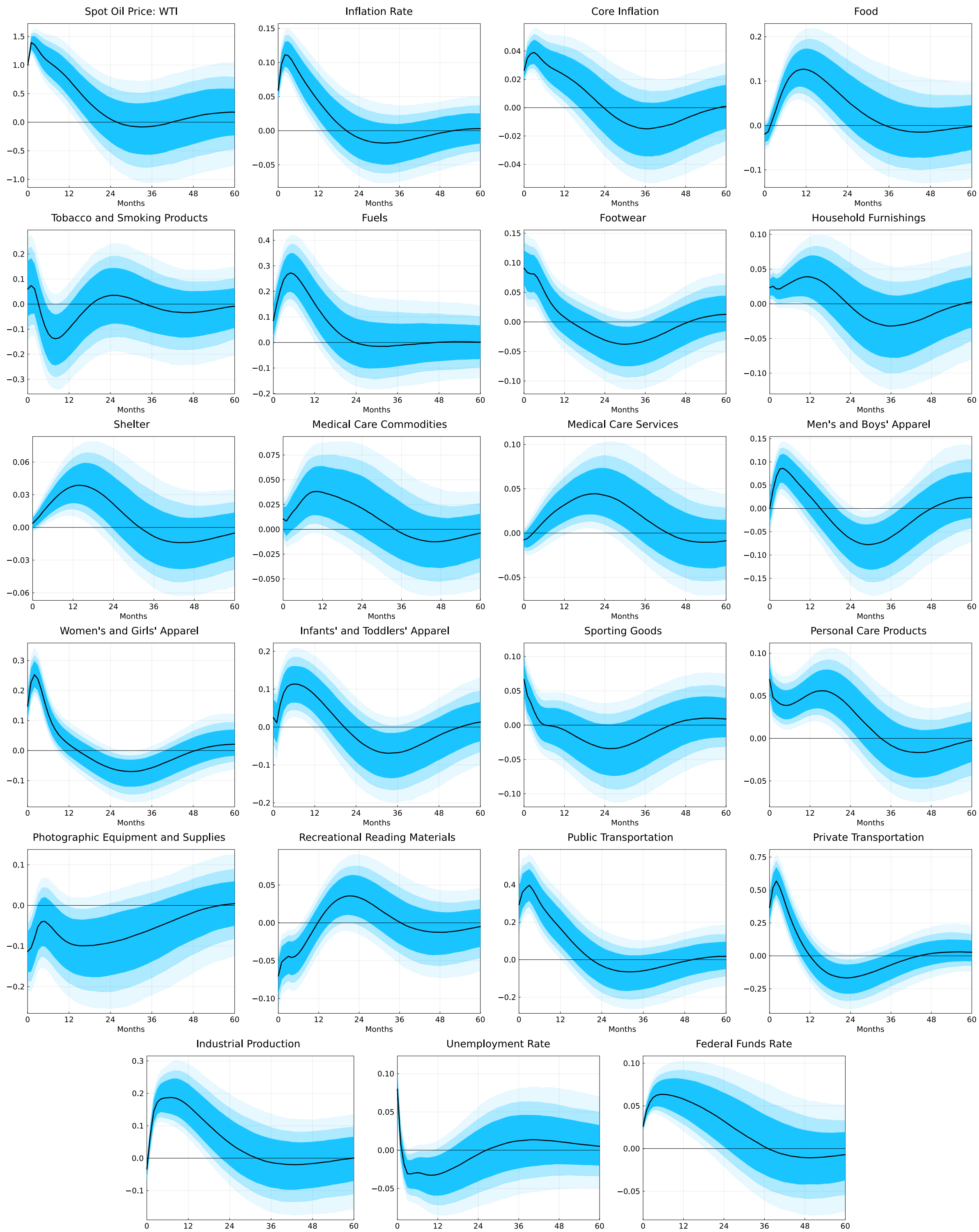
Turning to the US, we notice a larger impact at all lags but less persistence. Core is slightly more persistent than headline but it peaks after a few months, while returning to the steady state just after 2 years. The fact that core inflation has plateaued for a few months, is suggestive that other shocks

Figure 19: Euro area - Impulse Response Functions - oil supply shock - 1997-2022



Note: the parameters and the oil supply shock instrument are estimated over the sample 1997:01:01 -2022:30:09. The chart reports response to an oil supply shock which increases the WTI price by 1 dollar. Shaded areas are 68, 80 and 90 percent coverage ratios.

Figure 20: US Impulse Response Functions - oil supply shock - 1997-2022



Note: the parameters and the oil supply shock instrument are estimated over the sample 1997:01:01 -2022:30:09. The chart reports response to an oil supply shock which increases the WTI price by 1 dollar. Shaded areas are 68, 80 and 90 percent coverage ratios.

creating persistence might be at work. in this case. Also in this case we see an interesting pattern of dynamic heterogeneity with food and shelter lagging core. inflation.

There are two main results that we want to highlight. First, in both cases, the response to oil is heterogenous across sectors. Second, in the Euro area the response is more persistent than in the US. The impulse response for headline peaks after 12 months and takes about two years to go back to zero while core peaks after 24 months and declines to zero only after 60 months. In the US, the response of inflation is initially higher but it peaks after a few months while the response of core inflation reaches zero after 24 months.

The closed economy version of the model we propose in Chapter 3 will be able to qualitatevly replicate these results.

2.1.2 The response of sectoral inflation to oil supply shocks and to monetary policy shocks

Here we perform the analysis on US data since we have a longer sample available. The monetary policy shock is identified as the unexpected movement in interest rate futures around Federal Open Market Committee (FOMC) dates. To clean the variable from a component that may be determined by market' expectations on the future state of the economy, we follow Miranda-Agrippino and Ricco (2021) and consider the part of the monetary policy surprise that is orthogonal to both the central bank's economic projections and to past market surprises. Box 2.1 explains the procedure. As Fed's projections we use the Greenbook forecasts which are available until 2015. For this reason, our sample does not include 2016-2022. Our sample spans the 1975-2015 period.

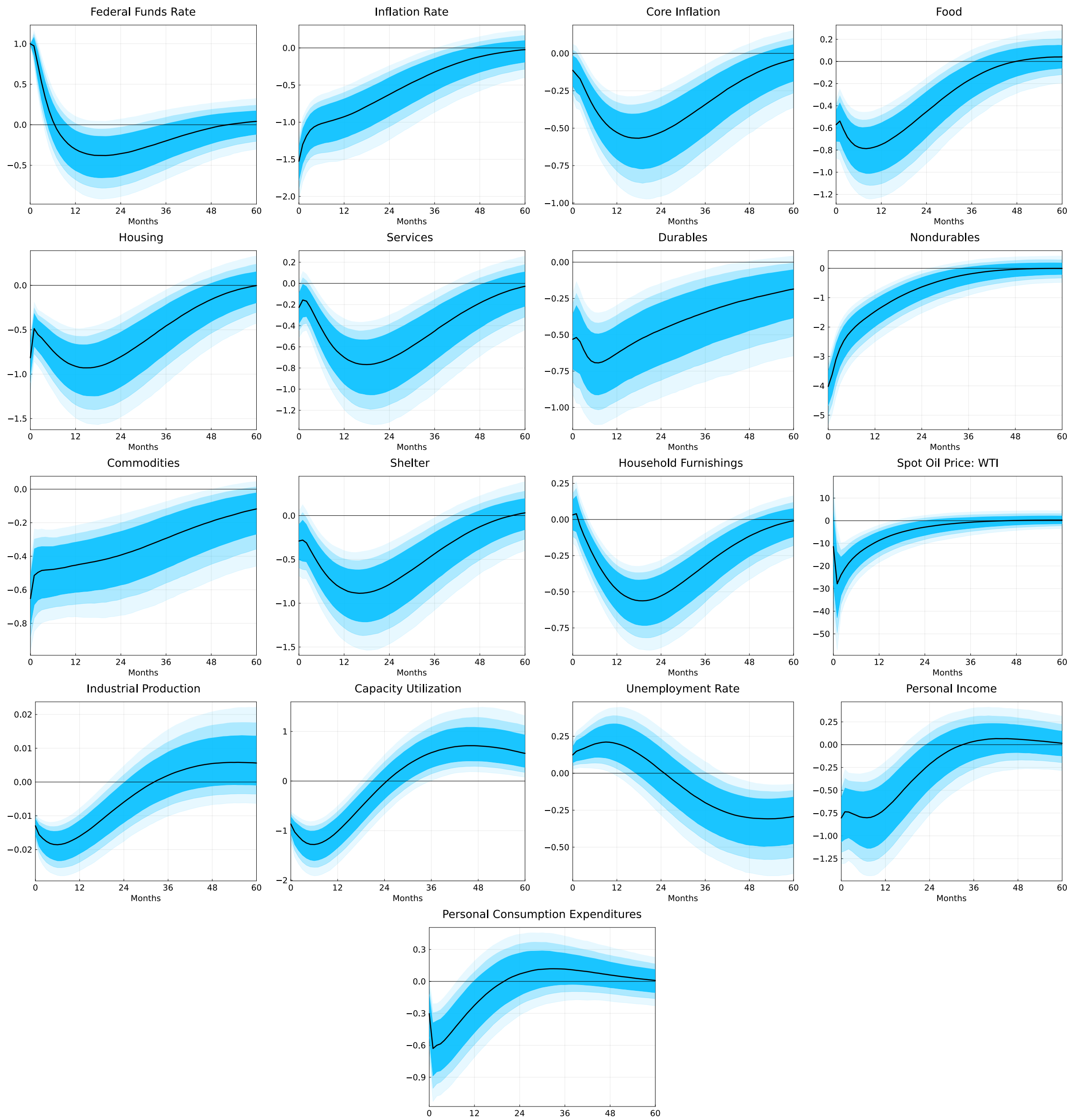
The level of disaggregation for price variables is smaller than in the previous specification because, in order to identify the effect of monetary policy, we need a more balanced panel of price and real variables. Since we want to compare the two exercises, we use the same specification for the two shocks.

Figure 21 shows the impulse response functions to a shock that increases the federal fund rate by 1%. Note that the size of the responses to the monetary shocks is not comparable with that to the oil shocks. The monetary policy shock is expressed in percentages, while the oil shock is expressed in $ terms. As a consequence, a response of 0.1 to a monetary shock means a 0.1% of a 1% while the same number for the oil shock means a 0.1% to a 1$ (over the steady state).

Starting from Figure 22 , we find qualitatively the same result as in the shorter sample for prices but this time the effect of an oil supply shock is clearly negative on real variables. This is possibly caused by the fact that from the new millennium, the US became a net oil exporter. .

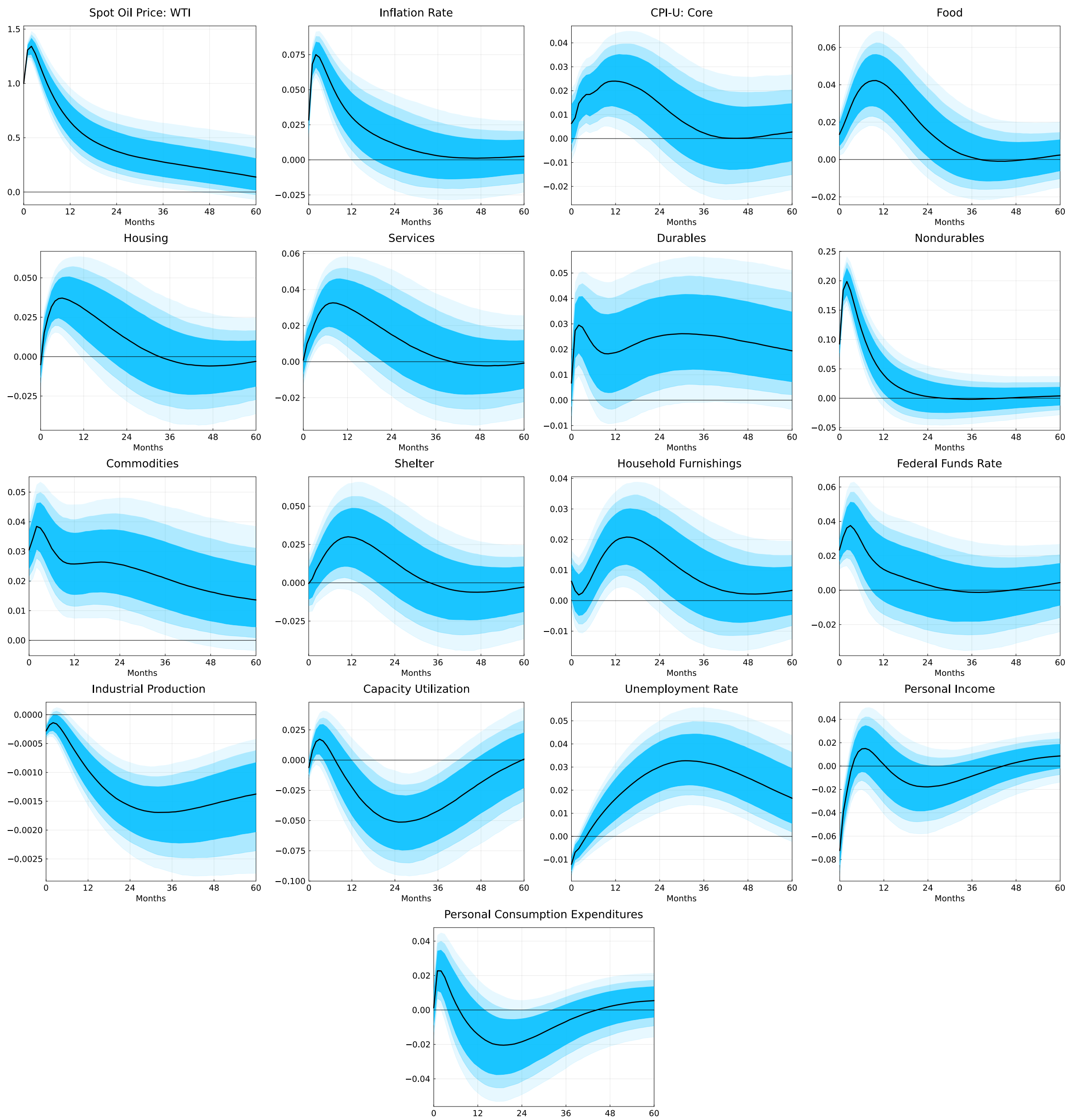
As for the monetary shock, we can detect some heterogeneity in the responses of inflation components

Figure 21: US - Impulse Response Functions to negative monetary policy shock - 1979-2015



Note: parameters are estimated over the sample 1979:1:1 - 2015:31:12 while the monetary policy instrument is from 1991:1:1. The charts report the response to a negative monetary policy shock which increases the federal fund rate by 1%. Shaded areas are 68, 80 and 90 percent coverage ratios.

Figure 22: US - Impulse Response Functions to an oil supply shock - 1979-2015

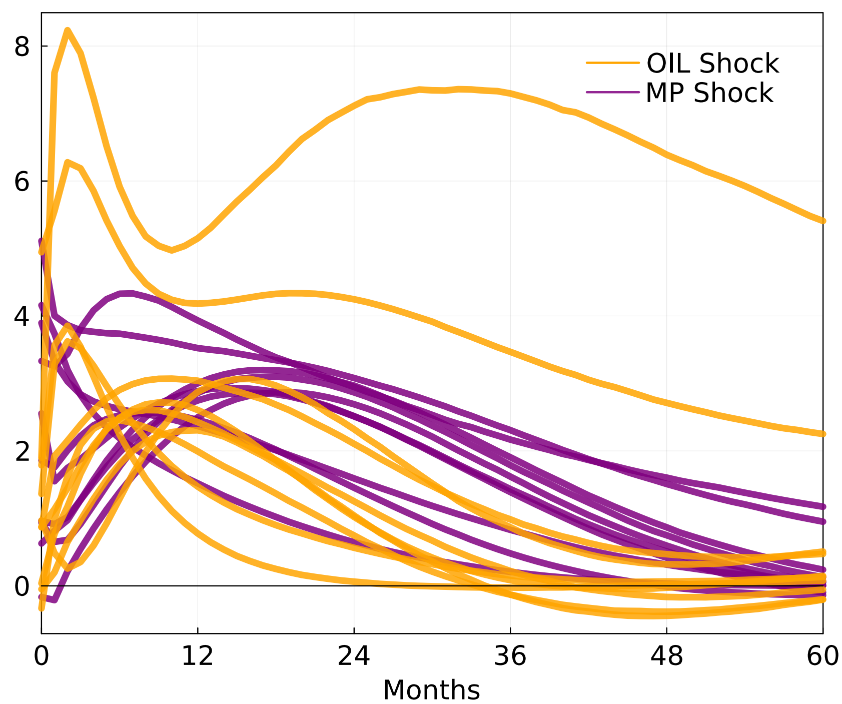


Note: parameters are estimated over the sample 1979:1:1 - 2015:31:12 while the oil supply shock instrument is from 1991:1:1. The charts report the response to a negative oil supply shock which increases the WTI price by 1 dollar. Shaded areas are 68, 80 and 90 percent coverage ratios.

- the reason being that a monetary shock has an effect on oil prices - but the heterogeneity is less pronounced that in the case of the oil shock.

To better visualize this, we have plotted the responses to the oil (orange) and monetary (purple) shocks, standardized by their own standard deviation, in the same chart. Standardizing this way, makes us lose any information on the size of the shock but helps comparing the shapes of the responses. In Figure 23, we are showing responses to a monetary easing shock and to a positive supply shock.

Figure 23: US - Impulse Response Functions to an oil supply shock and monetary policy shock - 1979-2015



Note: Impulse Response Functions are standardised by the own standard deviations.

The chart highlights the higher degree of dynamic heterogeneity of the responses to the oil shock. This feature will be qualitatively reproduced by the stylized model we present in the next Section.

BOX 2.1: VAR estimation and specification

The VAR model is defined as:

$$Y_t = A_0 + A_1 Y_{t-1} + \cdots + A_p Y_{t-p} + u_t \tag{1}$$

In all specifications, the VAR models have been estimated by Bayesian methods using a Normal Inverse Wishart prior and sum of coefficients prior. The tightness parameter is optimized using Bańbura, Giannone, and Reichlin (2010).

The structural shocks ϵ_t are related to the reduced form shocks as follows:

$$\epsilon_t = A_0^{-1} u_t \tag{2}$$

We are interested in identifying an oil shock and a monetary policy shock. Let's label them ϵ_t^o and ϵ_t^m respectively.

For identification we follow the "external" instruments approach suggested by developed by Stock and Watson, 2008 and Merterns and Ravn, 2012.

This implies selecting an external instrument, z_t, to identify the shock ε_t^i where $i = m, o$. The instruments must satisfy two conditions:

- *Instrument relevance:*
$$\mathbb{E}(\varepsilon_t^i . z_t') \neq 0 \tag{3}$$

- *Instrument validity (exogeneity):*
$$\mathbb{E}(\varepsilon_t^i . z_t') = 0 \tag{4}$$

Using a valid instrument gives consistent estimation of shock. Assuming that the shock of interest is ordered first, estimation of the monetary policy shock is done in three steps:-

1. Estimate the VAR model and obtain the residuals ($\hat{u}_t$).
2. In order to obtain elements of the column of the matrix (A_0^{-1}), say a_1, regress $\hat{u}_t$ on z_t.
3. Take the ratio of regression coefficients obtained from step 2 with the coefficient a_{11}.
4. Normalize as $a_{11} = 1$

Under these assumptions, the shock can be identified up to a scale by regressing the instrument on each innovation series.

Choice of instruments

Oil shock

The external instrument for the oil shock is the high frequency oil shock, identified as in Känzig (2021). We consider the surprise in the futures price for oil on the day in which the Organization of the Petroleum Exporting Countries (OPEC) has a meeting. The relevant time window over which the surprise takes place is between the day of the announcement and the last trading day before the OPEC meeting.

The key assumption is that the news revealed within the window that leads to the surprise in the futures price can be treated as exogenous with respect to the other variables in the VAR.

Monetary policy shock

For monetary policy surprises we follow the convention by using unexpected movements in interest rate futures around Federal Open Market Committee (FOMC) dates.

We follow Miranda-Agrippino and Ricco (2021) and consider that part of the monetary policy surprise that is orthogonal to both the central bank's economic projections and to past market surprises. This implies projecting the high-frequency market-based surprises in the fourth federal funds futures around FOMC announcements on Greenbook forecasts and forecast revisions for real output growth, inflation, and the unemployment rate and remove the autoregressive component. The projection controls for the central bank's private information while the removal of the autoregressive component accounts for the slow absorption of information by the agents.

2.2 Leading-lagging relationship between headline and core inflation in the euro area

In this section we present a simple Granger-causality test derived from a three-variable VAR including headline inflation, core inflation and the unemployment rate for the euro area for the sample 2000-2022. F-tests are reported in the table below.

Results clearly say that we cannot reject the hypothesis that headline inflation Granger causes core but that we can reject the hypothesis that core inflation Granger causes headline. This reflects the finding

Table 1: Granger Causality Test.

	F	df1	df2	ρ-value	χ^2	df	ρ-value
EA							
Inflation Rate $\Longleftarrow$ Core Inflation	1.59	3	264	0.192	4.77	3	0.189
Core Inflation $\Longleftarrow$ Inflation Rate	6.68	3	264	<0.001	20.05	3	<0.001
US							
Inflation Rate $\Longleftarrow$ Core Inflation	2.62	3	264	0.051	7.86	3	0.05
Core Inflation $\Longleftarrow$ Inflation Rate	5.55	3	264	< 0.001	16.64	3	< 0.001

that core inflation is a lagging indicator of headline in the EA case. The fact that core has not started declining as headline in the euro area may simply be a reflection of this lagged effect.

2.3 The 1970s and post-covid monetary policy

What does the comparison with the present inflation surge and those of the 1970s and 1980s say?

In Chapter 1 we have seen that the energy shock faced by the EA has been extraordinary: much bigger than what experienced in the 1970s if we consider trough-to-peak. However, the peak reached by headline inflation both in the US and the Euro area has been at a lower level than what experienced in the 1970s and early 1980s. This is not surprising since, in the latter episode, the oil shock hit after a prolonged period of expansionary fiscal and monetary policy which had started in the mid 1960s.

The historical account of those years show that the response to the supply shock related to OPEC I was chaotic.

Monetary and fiscal policy vacillated between easing and tightening in a stop-and-go fashion (see Blinder, 2021 and Bernanke, 2022). The conceptual framework on which that response was based underplayed the importance of price stability and commitment to a clear and credible target. Neither the Fed nor Congress considered inflation to be the primary target. Indeed, the Fed Act establishing the dual mandate was only passed in 1977.

OPEC-II stroke when inflation was already relatively high, having been driven by expansionary fiscal and monetary policy and being preceded by a steady increase in food price inflation since 1976. From October 1976 to April 1980, inflation went from 5.4% to 14.6%.

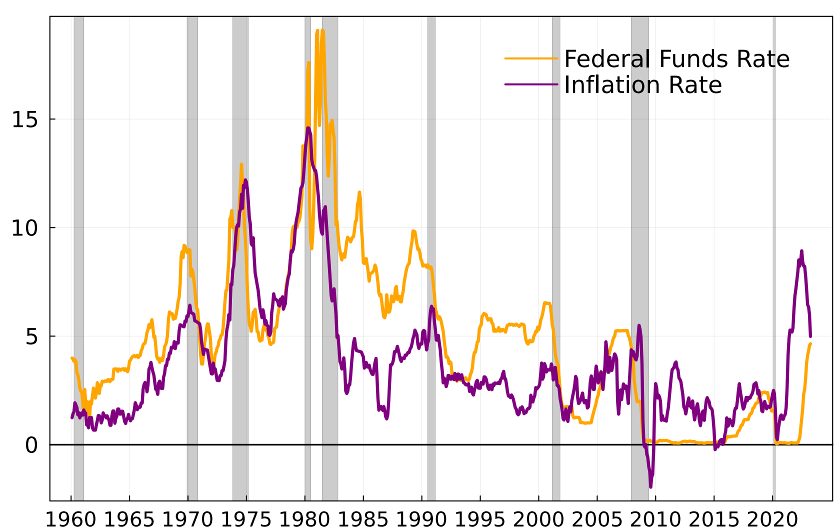
When Volcker was appointed, the Fed had lost the credibility on its ability or willingness to control inflation. However, the political will was maturing as it is demonstrated by the fact that in 1977 Congress established the dual mandate with the Federal Reserve Act.

Volcker's first attempt to tame inflation was soon reverted after a short recession materialised, the latter being partly explained also by credit controls implemented by the Carter administration. According to Alan Blinder's reconstruction, the post-recession increase in inflation coincided with credit controls being dismantled. At that point (September 1980), Volcker went for a sharp tightening.

For our discussion, it is is interesting to note that, at that time, the Fed acted with a delay and, by the time action was taken, the oil shock had subsided. At that point, the resurgent inflation was driven by demand: monetary policy tightened in response to an overheated economy in which the inflation anchor had been lost. Goodfriend and King (2005) document that the "incredible disinflation" that followed and the cost in terms of unemployment was the result of lost credibility. Once that credibility was established, Volcker could enjoyed a "credibility bonus". As we will argue more formally in Chapter 4, the Fed enjoys today that bonus as a result of two decades of low and stable inflation.

Interestingly, although Volcker's disinflation has been recognized as a textbook case for best practice, inflation remained between 3 and 4% until the second half of the ninenties although real interest rates remained high for historical standards. (The level of real interest rate cannot be considered as a measure of monetary policy stance without a view on the equilibrium rate. More on that in Chapter 4.)

Figure 24: Federal Funds Rate and Inflation Rate - 1960:2023



Source: Haver Analytics

The consequence of high interest rates was not only a prolonged recession, but also serious financial tensions. 1984 saw the crisis of a large bank, Continental Illinois, which, after having faced a ran on deposits, was bailed out. The S&L industry was the other victim. As interest rates raised, depositors withdrew funds to seek higher returns. As demand for mortgages declined, as a consequence of the tightening, and the cap on interest on deposits on S&Ls deposits was lifted in an attempt to halt the flight of depositors, many S&Ls became insolvent. Since deposits were insured, losses were passed on to taxpayers. What happened is nicely summarized by a quote from Volcker, as reported by Blinder. When asked how he thought monetary policy worked to crush inflation, Volcker replied: "by causing bankruptcies" (Blinder, 2022, pag 106).

We recently saw some financial tightening as a consequence of increased market risks showing indeed that the transmission of monetary policy through the financial sector is gaining traction. We will return to this discussion in Chapter 4.

CHAPTER 3: A stylized two-sector model with energy

A key feature of an energy price shock is that it hits the economy in an uneven fashion, affecting some sectors more directly than others. We think that this uneven nature of the shock is crucial to understand the behavior of inflation and relative prices. While we believe that other types of uneven shocks are behind the recent rise of inflation, including supply chains disruptions following the pandemic, here we focus on energy price shocks because they are relatively easier to identify in the data. However, many channels emphasized in the model would carry through following other shocks with uneven effects across the economy's supply side.

The crucial mechanism we want to investigate is how a supply shock that initially hits more one sector of the economy, will propagate gradually, before dying down, hitting other sectors with different lags. The mechanism of transmission depends on the input-output structure and on the labor market.

To generate the heterogeneity in relative price movements emphasized in the previous chapter, we need a multi-sector model. In the previous chapters, we also contrasted the different response to the energy shock in the US and in Europe. In particular, we emphasized a stark difference in the terms of trade responses in the two cases and the fact that household consumption has been much slower to recover in Europe than in the US. To capture these facts it is useful to capture in the model how much a country (or macro-region) is dependent on foreign energy imports. We do so by considering an open economy setting and changing the degree of external energy dependence in the initial steady state. Building on Guerrieri et al. (2021), we develop a two-sector open economy model with sticky prices and a scarce factor of production, which we label "oil". Our approach is closely related to the analysis of multi-sector Phillips curves in Rubbo (2020).

3.1 Relative price response to an oil shock in a closed economy

Let us first explore the transmission of supply shocks to sectoral inflation in a baseline closed economy. To keep the analysis simple, assume that there are only two sectors, say manufacturing and services. Manufacturing uses labor and oil as factors of production, while services uses labor as a primary factor and manufacturing goods as intermediate inputs. Labor is fully mobile between sectors and nominal wages are flexible. Box 3.1 describes the ingredients of the closed-economy model. The different exposure of the sectors to the energy supply shock, together with the production structure and price stickiness, generates heterogeneity in the inflation responses and relative price adjustments.

BOX 3.1: Closed-Economy Model

The economy features two sectors: sector A, which we label services, and sector B, which we label manufacturing. There is a continuum of infinitely-lived households who have standard separable and iso-elastic preferences over consumption C_t and labor effort L_t, where consumption is a constant-elasticity-of-substitution (CES) aggregate of the goods produced in the two sectors. Within each sector $s \in \{A, B\}$ there is a unit mass of firms $i \in [0, 1]$ that produce differentiated varieties Y_{sit} that are combined into the sector output according to a CES aggregator, with elasticity of substitution ε.

All firms in a given sector have the same technology. Namely, firm i producing in sector A has a CES production function with elasticity of substitution ν_B that requires labor, N_{iAt}, and intermediate goods produced in sector B, X_{it}, where X_{it} is itself a CES aggregate of all the varieties produced in sector B.

Each firm i producing in sector B also has a CES production function with elasticity of substitution ν_B, but uses as inputs labor, N_{iBt}, and a scarce good, like oil, Z_{it}. Oil is in fixed supply $\bar{Z}$ and $p_z t$ denotes its price. Firms in both sectors set prices a la Calvo, that is, each period an independently drawn fraction $1 - \theta_s$ of firms in sector s can reset prices, all other firms must keep their price unchanged. The optimal reset price for a firm in sector $s \in \{A, B\}$ is P^*_{st}, and is the price that maximizes the discounted value of profits over all future periods $t + k$ in which the firm has not been able to reset prices, that is,

$$P^*_{st} = \arg\max_{\tilde{P}_{st}} E\left[\sum_{k=0}^{\infty} \Lambda_{t,t+k}\theta_s^k Y_{ist+k|t}(\tilde{P}_{st} - (1-\tau)MC_{st+k})\right], \qquad (5)$$

subject to $Y_{ist+k|t} = Y_{st+k}\left(\tilde{P}_{st}/P_{st+k}\right)^{-\varepsilon}$, where $\Lambda_{t,t+k}$ is the stochastic discount factor, and τ is the subsidy that the government pays to the firms and is set at the industry level so that profit-maximizing price is equal to the pre-subsidy marginal cost. Notice that the marginal cost MC_{st+k} is independent of the firm's output due to the assumption of constant returns to scale. Following standard derivations, we obtain the following sectoral Phillips curves in log deviation from the steady state

$$\pi_{st} = \rho\pi_{st-1} + \lambda_s(mc_{st} - p_{st}) + (1-\rho)\beta\pi_{st+1}, \tag{6}$$

where the first element on the right-hand side adds an element of inertia (which can be micro-founded introducing a form of indexation), $\lambda_s \equiv (1-\theta_s)(1-\beta\theta_s)/\theta_s$ represents the degree of price stickiness in the sector, and the marginal costs are

$$mc_{At} = \alpha_A w_t + (1-\alpha_A)p_{Bt} \text{ and } mc_{Bt} = \alpha_B w_t + (1-\alpha_B)p_{Zt},$$

where α_A and $1-\alpha_A$ are the steady state shares of labor and of the intermediate input B in the gross output of sector A, while α_B and $1-\alpha_B$ are the steady state shares of labor and of the energy input in sector B.

Our main experiment is a transitory negative shock to the supply of oil. The economy's response depend both on the supply shock and on the monetary policy response. In our main example, we consider what happens when monetary policy keeps total employment stable.

Figure 25 shows how the economy responds to such a shock. The top left panel shows the increase of the oil price, which responds endogenously to the reduction in oil supply. The top right panel shows the response of employment (solid blue line) which, by our assumption on monetary policy, is set to zero. For reference, we are also plotting the flexible price response of employment (dashed red line). The fact that the employment response in the flexible price case is negative implies that under our monetary policy assumption the central bank is keeping employment above its natural level. Notice that this does not mean that monetary policy is easing, as we'll discuss more in detail when we look at the consumption response. It just means that monetary policy is not sufficiently contractionary to mimic flexible-price employment.

The middle left panel is the crucial one. It shows how inflation responds differently in the two sectors and shows that this simple model can replicate, albeit in a stylized way, the observation from the empirical analysis above: the sector which uses oil directly (sector B in red) shows a fast response; the response of inflation in the other sector (sector A in blue)—which uses oil only indirectly through the intermediate goods—is weaker early on, but then builds up and produces a second wave of inflation. The differential responses produced by the model echo the impulse responses in Figures 22 and 19, which show that sectors that use oil more directly experience faster and deeper responses. The yellow line plots total inflation and shows that the underlying heterogeneous responses in sectoral inflation rates translate into an overall more persistent response of total inflation.

To understand this two-wave response it is useful to briefly discuss the sectoral Phillips curves. The model features two sectoral Phillips curves, that capture the effects of optimal, staggered price setting. The fundamental force that drives inflation in both sectors is the distance between nominal marginal costs in the sector and the current price level in that sector. Marginal costs in sector B are immediately affected by oil prices, which causes inflation in that sector to immediately pick up. However, due to stickiness, the nominal price of B increases only gradually. As the price level in sector B increases, it increases nominal marginal costs in the service sector A, given that good B is used as an intermediate input in sector A. This implies that the price response of services is delayed, hence generating a persistent effect on overall inflation. The specific degree of delay in the service sector relative to the goods sector clearly also depends on the degree of price stickiness.

Notice that the input-output structure is not the only channel of transmission across sectors. Another important transmission occurs through the labor market, via the adjustment in nominal wages. In the current version of the model, this adjustment takes place quickly: as nominal prices in sector B pick up, the overall CPI increases; this leads workers to ask higher nominal wages to make up for the lost purchasing power. In turn, this increases marginal costs and hence inflation rates in both sectors.

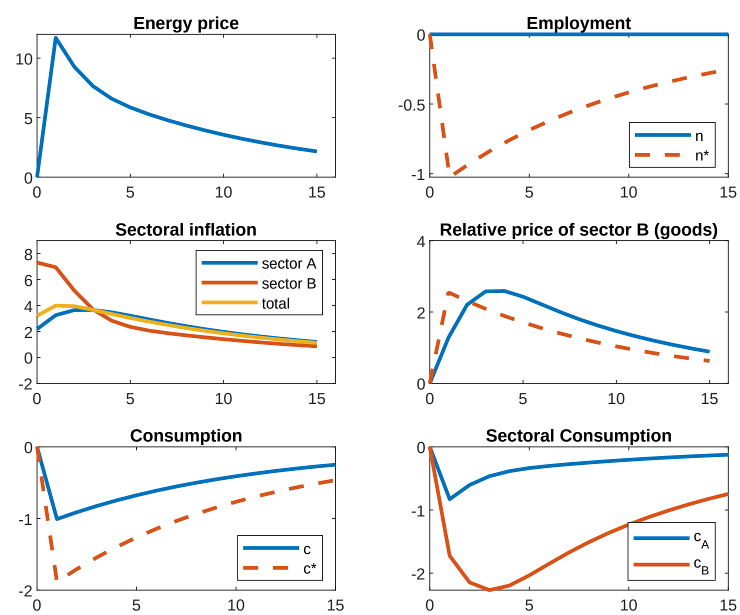
For simplicity in this model we assumed fully flexible wages. It would be easy to add wage stickiness, which, not only would produce additional persistence in the inflation response, but would also increase the delay between the responses of the two sectors. Introducing sticky wages is formally analogous to introducing a third sector that produces labor services, so in that sense the effect would be a transmission from sector B, to the labor sector, and finally to sector A. Notice that recent work on wage-price spirals by Lorenzoni and Werning (2023) also emphasizes a multi-wave interpretation of inflation, focusing on the delayed response of nominal wage inflation. The labor market side of the model also provides a partial dampening effect of the channels discussed so far, due to the fact that weaker consumption (which we discuss shortly) will lead to weaker real wage demands by workers, through a standard income effect on labor supply. Blanchard and Gali (2007) introduce real rigidities in labor supply that partly mute that channel.

Going back to Figure 25, the blue solid line in the right middle panel shows the behavior of the relative price of manufacturing goods (sector B). The dashed red line in the same panel shows the response of the same relative price in an economy with flexible prices. The figure shows that price stickiness generates delay in the relative price adjustment.

The bottom panels show what happens to household consumption. The left panel compares total consumption (blue solid lines) to its flexible-price level (red dashed lines), and shows that consumption drops less in the presence of sticky prices. This is simply a reflection of the fact that the central bank is keeping employment above its natural level. Notice that the consumption path is increasing after the shock, which, from the consumer Euler equation, implies that the real interest rate is temporarily higher. This justifies our previous claim that the central bank's response in this simulation is contractionary.

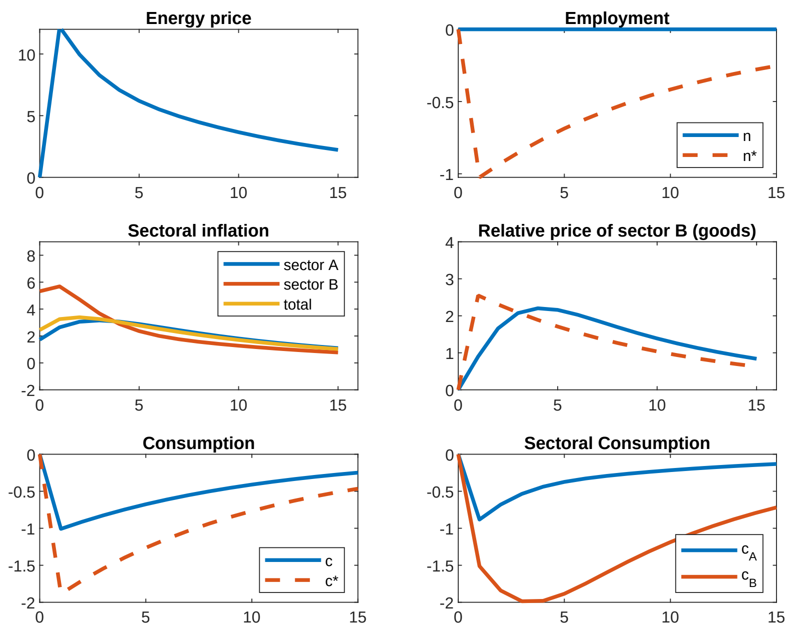
Finally, the right bottom panel shows how households shift consumption between the two goods in response to the shock. The figure shows that consumption in both sectors decline, but it does so more in the manufacturing sector (the one directly affected by the shock) in response to the increase in that sector's relative price.

Figure 25: Closed economy's response to an oil shock



To sum up, the persistent effect of inflation is the effect of the uneven effect of oil prices in the two sectors combined with price stickiness. This implies that the degree of price stickiness in the economy and the degree of substitutability between the two goods and between different factors of production are key parameters of the model that affect inflation dynamics. In particular, given that there is a large literature emphasizing the fact that the Euro area features more price stickiness than the US, we now explore the effect of the same oil shock in an economy where prices are more sticky. Figure 26 shows the response of a closed economy to the same contraction in oil supply as in figure 25 when the price in sector B are more sticky. The figure shows that in this case the shock generates a smaller response in overall inflation, and, especially, in inflation in sector B, but larger persistence, as the hump in total inflation is delayed relative to the benchmark. These model's implications are consistent with the VAR analysis in the previous chapter. In particular, Figures 20 and 19 show that in response to the same energy shock, the Euro area experienced smaller but more persistent inflation.

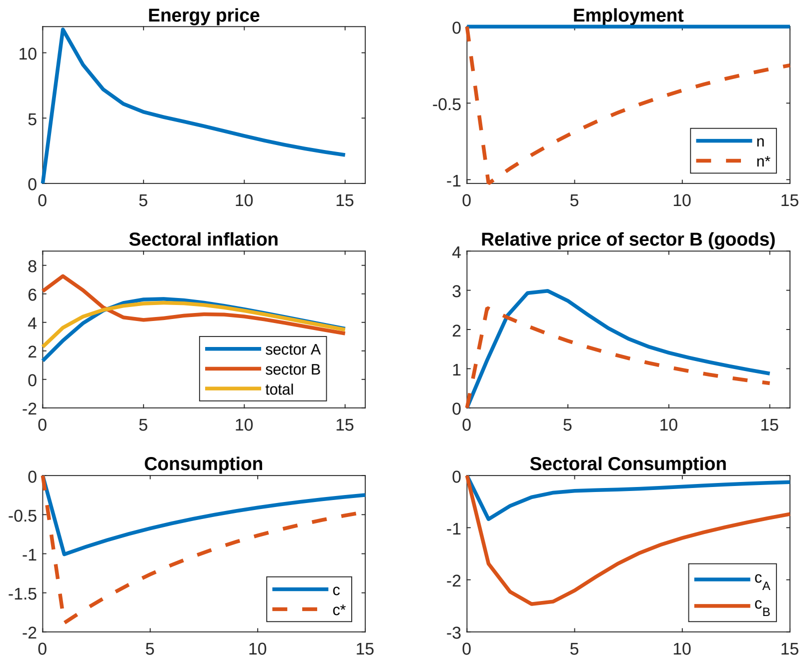
Figure 26: Economy with higher degree of price stickiness



In the model, we also introduce inertia in inflation dynamics driven by a form of indexation. Naturally the degree of persistence of inflation also crucially depends on how strong this force is. Figure 27 shows the response of an economy where the degree of inertia is larger than the baseline economy and shows that this increases both the level and the persistence of inflation.

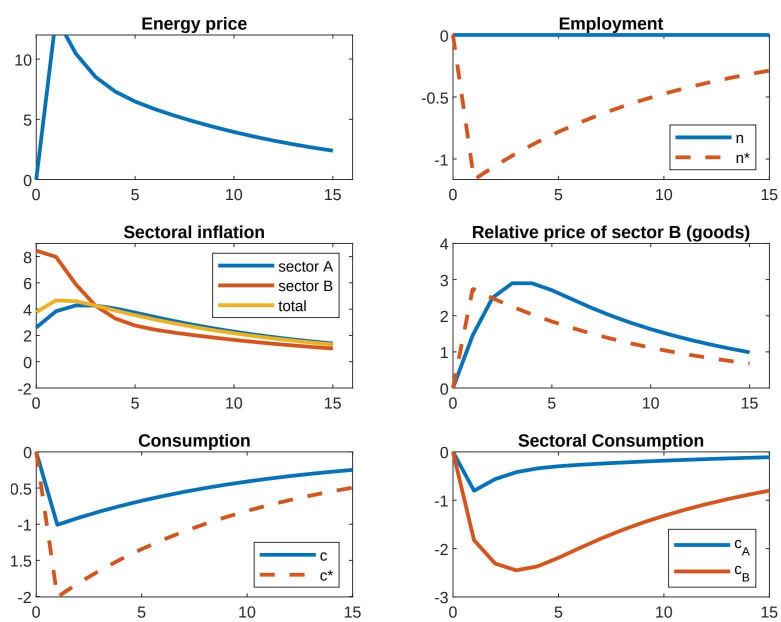
Another interesting comparative statics is with respect to the elasticity of substitution between labor and oil in sector B. Figure 28 shows that when labor is a better substitute for oil, then an oil shock would have smaller effects on inflation because the economy will respond by using more labor in sector

Figure 27: Economy with smaller degree of indexation



B. However, this implies that the relative price in sector B will increase less than what would happen in the flexible price economy, generating a larger drop in consumption.

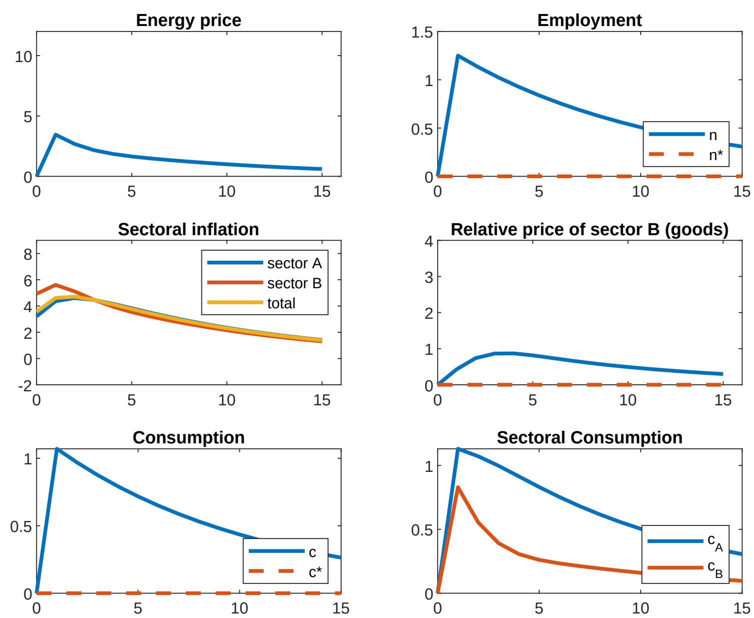
Figure 28: Economy with lower elasticity of substitution between labor and oil



3.2 Monetary policy implications

In thinking about monetary policy, a first natural question is whether total and sectoral inflation in this economy would respond differently to an even shock, such as a monetary policy shock. Figure 29 shows the response of the economy to an aggregate demand shock, that is, an increase in aggregate consumption, that generates the same increase in total inflation on impact. The figure shows that an aggregate demand shock generates much less heterogeneity in sectoral inflation than an oil price shock, as the demand pressure affects the market for all goods. It is interesting to notice that there is still some degree of heterogeneity, which is due to the fact that oil prices increase a bit in response to the aggregate shock, so the same effects of an oil shock apply but in smaller scale. This is consistent with the VAR analysis in the precious chapter that shows that for both the Euro area and the US there is a smaller degree of sectoral heterogeneity in response to a monetary shock than in response to an energy price shock. Notice, that in the model the response of the economy to a monetary policy shock is identical to the response to any other aggregate demand shock that hits all the sectors in the same way.

Figure 29: Closed economy's response to an aggregate demand shock

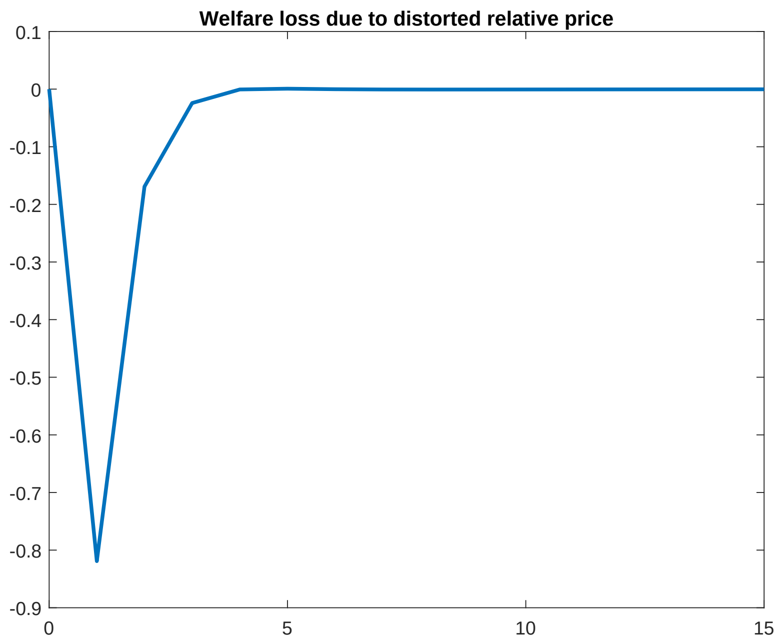


Given that the model, although stylized, is able to replicate some salient features of the data, we can now use it to explore some policy implications. In particular, the previous exercises have emphasized that relative price movements are efficient in response to an uneven shock, while they are not in response to a shock that hits all the sectors in the same way. A natural question arises: should the monetary policy stance be different in response to a shock that has more heterogeneous effects on sectoral inflation or not? To address this issue, Figure 30 shows the response of the economy to the same oil shock of Figure 25, but assuming that in each period after the shock employment is set equal to the employment level in the flexible price version of the model. This case can be thought as an economy where the Central Bank follows a tight monetary policy with a pure stabilization objective.

Figure 30: Closed economy's response to an oil shock with tight monetary policy

In comparing Figure 25 and Figure 30, we can see that, while the tight monetary policy helps reducing inflation to zero, it cannot replicate the relative price movement of the flexible price economy. In fact, the relative price of good B increases much less than in the flexible price economy and with more delay, generating distortions in the allocation of resources, and hence lower consumption. In particular, in response to the oil shock it is efficient to reallocate labor from sector B, which uses oil directly, to sector A, which uses oil only through intermediate goods. The figure shows that this is the case, as consumption of good B declines more than consumption of good A. However, in the flexible price economy, there would be a larger reallocation of resources thanks to the larger and faster increase in the relative price of good B. Hence, a tight monetary policy, by containing inflationary pressures, reduces the relative price adjustments that are necessary to obtain the right allocation, hence reducing welfare. In the log-linearized model consumption drops as in the flexible price counterpart, because the Hulten theorem applies. However, the distortions in relative price adjustment has sizeable second order effects that reduce consumption and welfare in the full non-linear model. Figure 31 shows the loss in welfare due to the distortion in relative price changes between the two sectors (assuming that all firms in each sector set the same average price to abstract from further welfare losses coming from dispersion within each sector).

Figure 31: Closed economy's response to an aggregate demand shock



To sum up, Figure 30 shows that a tight monetary policy although is successful to reduce aggregate inflation, generate distortions in the relative price movement across sectors. This inefficient relative price movements do not show up in lower consumption in the log-linearized model, but have sizeable second-order effects in the full model, as appears from Figure 31. Figure 25 shows that keeping employment constant would be too expansionary, by generating a drop in consumption smaller than the natural level and high inflation at the same time. An analysis of optimal monetary policy is beyond the scope of this paper, but these exercises suggest that the optimal policy would probably be somewhere in the middle. Overall, the main take away is that when we conduct monetary policy to fight inflation we want to be cautious and keep in mind that accepting a degree of short term inflation may be a necessary cost to allow for relative price movements that help obtaining a better allocation of resources.

3.3 Small open economy and terms of trade

The war in Ukraine has largely contributed to the substantial rise of energy prices in many European countries. This was particularly due to the fact that Russia was one of the main suppliers of natural gas, which was used in many European countries. In order to think about such a shock, we need to extend our model to consider an an open economy that may be a net importer of energy. For ease of exposition, we discuss the impact of an oil price rise, although the model could be easily used to analyse a rise in the price of natural gas or other commodities.

In the next Box we describe the extended version of the model, where we assume that the economy is open and the energy price shock is an increase in foreign oil price. In particular, we focus on a small open economy and for simplicity we make the extreme assumption of financial autarky. We assume that the economy imports oil from abroad (on top of a fixed domestic supply) in exchange for exporting manufacturing goods. This version of the model is better suited to think about European economies, where oil (and natural gas) is mostly imported, while the closed version of the model is better suited to think about the US, which mostly used domestic oil. Contrasting the open and closed versions of the economy is helping us reconcile at the same time the different pattern of terms of trade and the different recovery path of households consumption in Europe versus the US.

BOX 3.2: Open Economy Extension

We now extend the model to a small open economy. We assume that on top of the domestic fixed supply of oil $\bar{Z}$, there is a fully elastic supply of oil abroad that is traded at an exogenous price P^*_{Zt} in exchange for good B. The price of domestic oil then is going to be

$$P_{Zt} = S_t P^*_{Zt},$$

where S_t is the exchange rate. To keep the model simple, we make the stark assumption that the economy is in financial autarky. Given that oil is traded in exchange of goods produced in sector B, the balance of payment requires

$$P_{Bt} C^*_{Bt} = S_t P^*_{Zt} \left(Z_t - \bar{Z}_t \right).$$

The world demand for good B depends on the relative price of that good and on exchange rate. In particular,

$$C^*_{Bt} = C^*_B \left(\frac{P_{Bt}/S_t}{P^*_t} \right).$$

To sum up, the market clearing conditions for the two goods show that good A is only consumed domestically, while good B is consumed domestically, abroad, and used as intermediate input, that is,

$$Y_{At} = C_{At} \text{ and } Y_{Bt} = C_{Bt} + C^*_{Bt} + X_t,$$

where X_t is the total demand for intermediate inputs.

Figure 32 shows the response of a small open economy to an oil shock, when keeping the employment level constant. In particular, to make it comparable to the shock to the closed economy represented in Figure 25, we increase the foreign oil price so as to obtain the same increase in the domestic oil price as the one generated by the reduction in domestic oil supply in the closed economy. The figure shows that the response of total and sectoral inflation is qualitatively similar, although in the open economy both total and sectoral inflation move a bit more. However, the more pronounced difference between the two economies is the response of households consumption. In the open economy, the drop in total consumption is much more pronounced than in the closed economy. This is due to the fact that in the open economy, the drop in foreign oil prices act as a negative income shock, while in the closed economy the revenues of the oil sectors go back to the representative household. A different way of looking at the same issue is that the terms of trade of an energy-importing country deteriorates so the country overall is poorer. This is consistent with figure xxx in Chapter 1 that shows that the terms of trade in Europe have deteriorated unlike in the US, while the households consumption dynamics in Europe have been weaker.

Figure 32: Small open economy's response to an oil shock

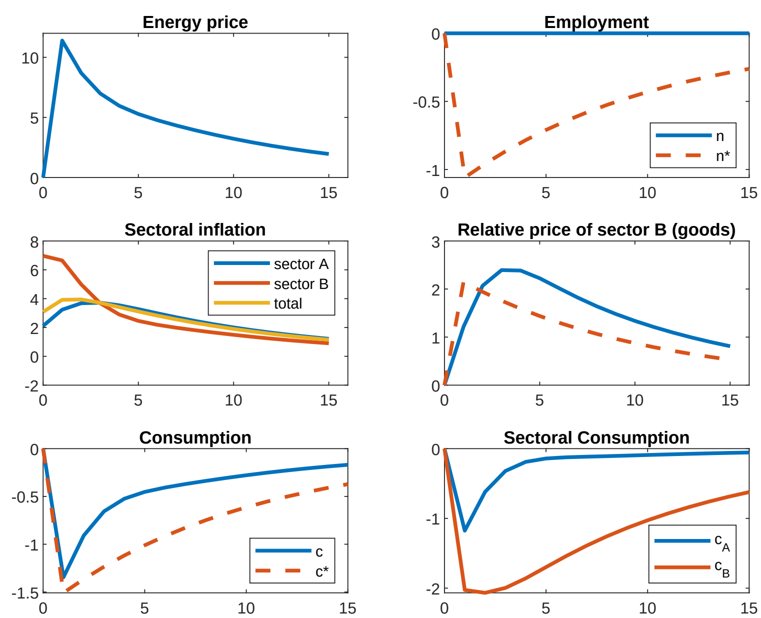
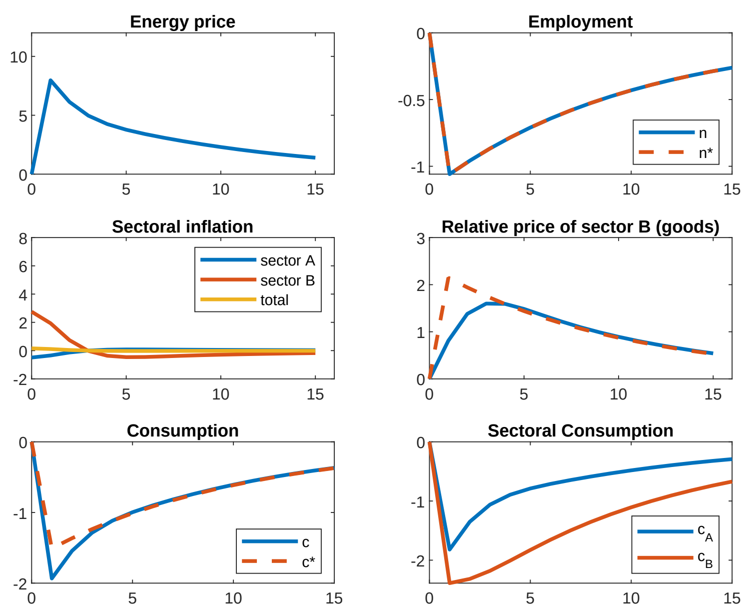


Figure 33 shows the response of an open economy to the same foreign price shock, when employment behaves as in the flexible price economy. The figure shows that as in the closed economy, a tight monetary policy that aims at keeping employment at the natural level, is able to keep inflation at zero, but generates too little movement in relative prices and hence an inefficient allocation of resources that generates a drop in total consumption below the flexible price counterpart. As in the closed economy case, the relative price of good B increases in response to the increase in oil price, but not enough relative to the flexible price counterpart, so there is not enough reallocation of labor to sector A on impact in response to the shock. However, in the open economy, consumption drops even more than in the open economy because of the exchange rate effect. In particular, because of the deterioration of the terms of trade, the economy has to export more manufacturing goods, depressing the domestic consumption even further.

Figure 33: Small open economy's response to an oil shock with tight monetary policy



Chapter 4. The Market View

The fist section of this chapter assesses the extent of tightening in financial conditions already underway in response to monetary policy actions. It puts the characteristics of the current tightening cycle in perspective by comparing them with the historical evidence. To this end we select various indicators of financial tightening and group them into buckets, including output or recession-risk measures, and financial measures. To complement the analysis, we also consider indicators of global price pressures. We focus primarily on the US owing to data availability.

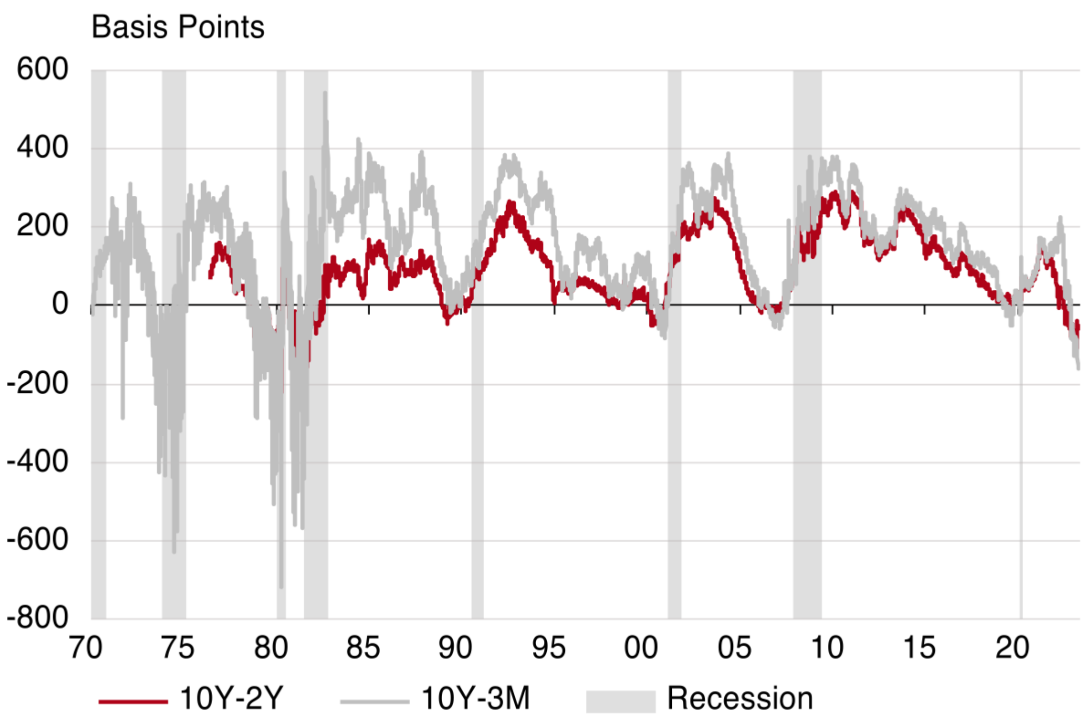
The second section analyses inflation expectation data and asks whether they remain anchored. The analysis follows the CBO (cite) and carries out a decomposition of various measures of inflation expectations to assess the strength of anchoring over time.

Finally, the third section studies bond yields to gauge inflation and real risk premia.

4.1 Effective tightening via financial conditions

As a first step to assess the extent of current tightening, we explore indicators of recession risk. Starting with the US yield curve, Figure 34 plots the 10 yr - 3 months and the 10 year - 2 year bond yields spreads. The yield curve shows an inversion, which is often interpreted as a signal of recession, though there could be other factors than increased recession risk behind it[2]

Figure 34: US Yield Curve: term spreads

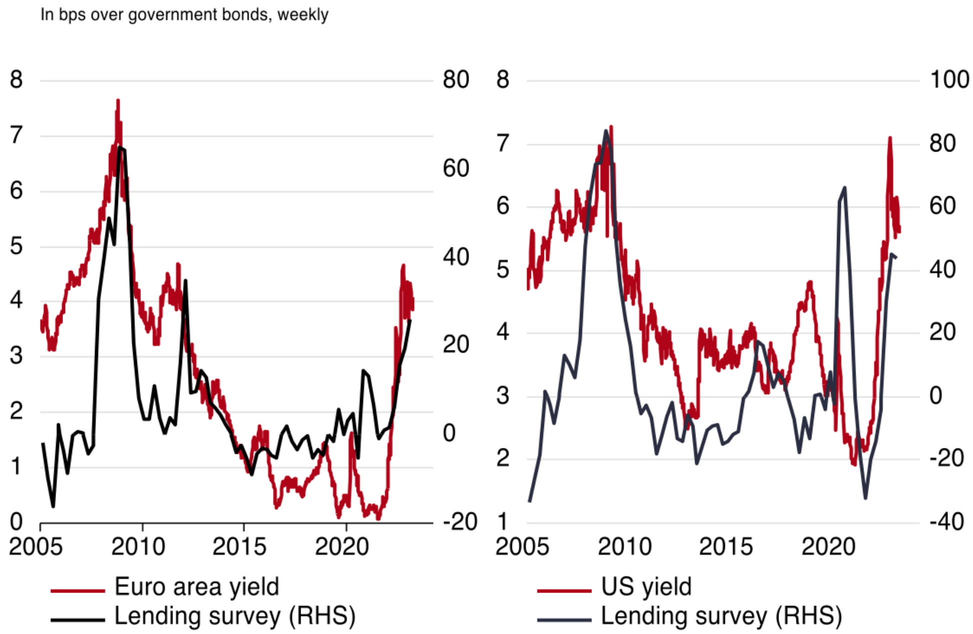


Source: Refinitiv and Bloomberg

As additional indicators, Figure 35 plots credit spreads and the outcomes from surveys of lending conditions for the US and the Euro area. They both show a sharp increase, suggesting a material tightening.

[2]For example, Goldman Sachs, 2023 judges that it rather rather signals a well anchored expectations of secular stagnation over the medium term.

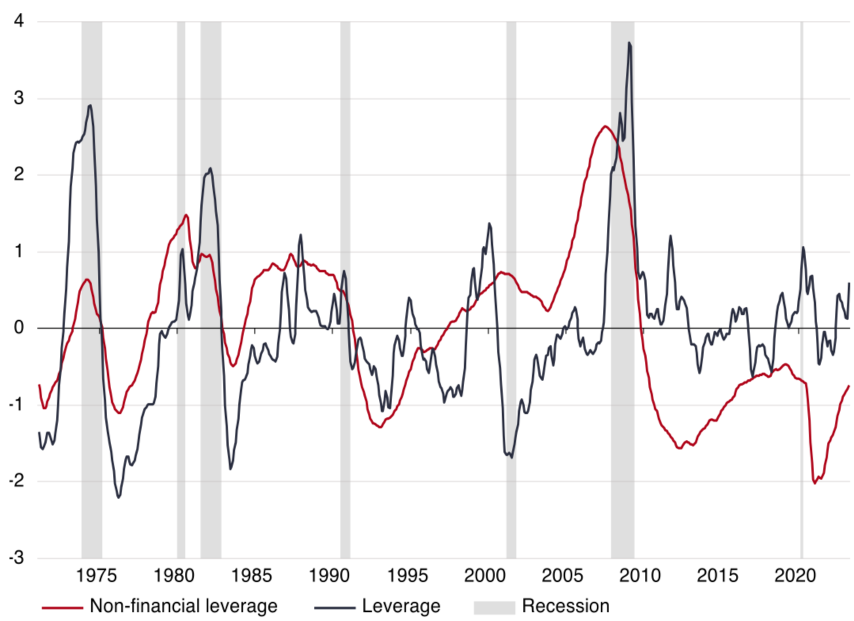
Figure 35: BBB Corporate Bond Yields and Lending Survey: US and Euro area



Source: Refinitiv

An indicator that is sometimes used as a signal of recession risk is the non-financial leverage component of the Chicago Fed's Financial Conditions Index (cite here). This is plotted in Figure 36, together with total leverage. It shows that, although overall non-financial leverage remains well below previous highs, it has recently increased sharply.

Figure 36: Sub-indicies from the Chicago NFCI: leverage and non-financial leverage



Source: Refinitiv

Broadening the number of indicators and the types of risks considered, we construct heat-maps of the extent of tightening using on output or recession-risk measures and financial measures. We also explore what, market's price-based measures are telling us regarding global inflationary pressures.

In selecting these various indicators, we gave priority to those with a long history and selected those with higher frequency availability. While the selected measures have strong inter-connectedness and some could arguably also be placed into other buckets than the one selected, we have decided for the sake of simplicity to include each metric in just one bucket.

We prefer this approach to just looking at broader composite financial condition indices (FCI), as these weigh together various components and conflicting signals may thus cancel out.

In the output or recession risk, we group indicators of the interest rate and leverage channels as they are key to the financing costs of the real economy. The non-financial sub-component index of the Chicago Fed NFCI is also included as it is understood to be a leading indicator of the economic cycle although it is also relevant as a potential warning indicator of financial stability risks. The financial indicators group includes the ratio of bank equity-to-non equity stock , seen as simple proxy for banking sector strength, the Shiller PE, realized volatility for the S&P over 30 days and the main Chicago NFCI sub-indices, noting that the leverage sub-index is typically a leading indicator, the risk sub-component as coincident and the credit sub-index as lagging [CITE?]. The total index is included for reference.

These two buckets serve as indicators of financial tightening. We also explore price-based measures, which might be inversely affected by tightening (i.e., tightening would cause an easing in global prices pressures); this group includes various indicators that may influence US inflation, covering oil, the trade weighted dollar, the raw materials and foodstuff indices from the CRB [please define] and the Baltic Dry Index. We further include the Cleveland Fed 1-year inflation expectations as a measure of inflation expectations. We select this rather than market breakevens due to the longer data history.

The classification is described in Table 2.

Table 2: Indicators selected (dates in brackets give the times series start year)

Output Risks	**Price-based Measures**	**Finacial Measures**
Effective FED funds Rate	OIL (Brent)	US Bank to non-financial equity indices
Real Effective FFR gap to the LW natural rate	US TW broad dollar index	US Shiller PE
10Y Tresury Yield	CRB Raw Industrials	S&P Realised Volatility
US 30Y Mortgage	CRB Food	Chicago FED NFCI Leverage
Moody's US Corporate Baa spread	Baltic Dry Index	Chicago Fed NFCI Risk subindex
Moody's US Corporate Aaa spread	Cleveland Fed, 1-year inf. exp.	Chicago Fed NFCI Credit subindex
Chicago NFCI non-financial leverage	CRB Food Commodities	Vix 3M
Chicago NFCI Non-financial leverage subindex		Chicago Fed NFCI (Total)

On this basis, we construct heat-maps for all three sets of measures. In all maps, a raw corresponds to a tightening monetary policy cycle as classified in Kwan et al (2023). The first column reports the duration of the cycle in months and the following columns the various indicators divided into total change and average change per month. Total change indicates the latest value compared to the start of the tightening cycle, the monthly averages are thus this change divided by the duration of the tightening cycle. For the present cycle, we count the months to date. Intensity of color signals the intensity of tightening.

Let us start with output or recession risk, as displayed in Figure 37. The results show that the effective fed funds rate tightening in the present cycle is one of the most significant on record. All the yield and credit spread metrics have also seen substantial increases, indicating a significant tightening of financial conditions for households and corporates. The dominant colour on the output risk category based on the market signals thus balances to orange.

Figure 37: Selected indicators over FED tightening cycles: output risk

Start	End	Duration in months	Effective funds rate (Nominal)		Real Effective funds rate (CPI) - LW natural rate of interest		10Y Us Treasury yield		US 30Y Mortgage Yield		Moody's Baa US Corporate		Moody's Aaa US Corporate		Chicago Fed National Financial Conditions Nonfinancial Leverage Subindex	
			Total change in basis points	Average change per month	Total change in basis points	Average change per month	Total change in basis points	Average change per month	Total change in basis points	Average change per month	Total change in basis points	Average change per month	Total change in basis points	Average change per month	Total change, actual	Average change per month
Dec-65	Nov-66	11	144	13			47	4			111	10	67	6		
Dec-68	Aug-69	8	317	40	218	27	0	0			63	8	52	6		
Apr-71	Aug-71	4	141	35	101	25	20	5	40	10	31	8	34	9	0.02	0.01
Feb-72	Sep-73	19	749	39	399	21	86	5	154	8	40	2	36	2	1.19	0.06
Mar-74	Jul-74	4	357	89	282	71	48	12	106	27	86	22	71	18	-0.21	-0.05
Apr-77	Apr-80	37	1288	35	429	12	331	9	712	19	512	14	400	11	1.99	0.05
Feb-81	Jun-81	4	317	79	488	122	43	11	132	33	43	11	40	10	0.15	0.04
Jul-83	Aug-84	13	227	17	15	1	101	8	73	6	124	10	72	6	0.84	0.06
Mar-88	Mar-89	12	327	27	206	17	73	6	114	9	10	1	41	3	-0.13	-0.01
Feb-94	Apr-95	14	280	20	175	13	93	7	94	7	84	6	95	7	0.70	0.05
May-99	Jul-00	14	180	13	14	1	41	3	90	6	63	5	72	5	0.24	0.02
Apr-04	Jul-06	27	424	16	193	7	47	2	71	3	30	1	12	0	1.75	0.06
Dec-16	Feb-19	26	186	7	184	7	27	1	3	0	11	0	-27	-1	0.19	0.01
Jan-22		15	475	32	645	43	181	12	272	18	198	13	159	11	0.65	0.04

Source: Refinitiv and Bloomberg

Turning to the financial risk measures, displayed in Figure 38, we note that our selected indicators for banks signals some tightening, although the ratio has improved since the turmoil in March. Equity valuations and volatility have also tightened. The various measures of the Chicago NFCI, show the leverage sub-component have been tightening. The dominant colour on financial stability thus seems to lean to yellow, which confirms a solid tightening financial conditions.

As anticipated, we also look at price-based measures, which might be affected by tightening, as we

Figure 38: Selected indicators over FED tightening cycles: Financial measures

Start	End	Duration in months	Banks-to-Non financial equities		Shiller PE (S&P)		S&P Realized volatility		Chicago Fed National Financial Conditions Leverage Subindex		Chicago Fed National Financial Conditions Risk Subindex		Chicago Fed National Financial Conditions Credit Subindex		Chicago Fed National Financial Conditions Index	
			Total change, %	Average change per month	Total actual change	Average change per month	Total change, in pp	Average change per month	Total change, actual	Average change per month	Total change, actual	Average change per month	Total change, actual	Average change per month	Total change, actual	Average change per month
Dec-65	Nov-66	11														
Dec-68	Aug-69	8														
Apr-71	Aug-71	4							0.21	0.05	0.62	0.15	0.06	0.01		
Feb-72	Sep-73	19			-1.89	-0.10	3.45	0.18	3.82	0.20	1.53	0.08	1.39	0.07	1.63	0.09
Mar-74	Jul-74	4	-16%	-0.04	-2.73	-0.68	7.22	1.81	-0.09	-0.02	4.30	1.08	0.89	0.22	4.28	1.07
Apr-77	Apr-80	37	-7%	0.00	-2.44	-0.07	9.27	0.25	2.69	0.07	3.92	0.11	4.91	0.13	4.56	0.12
Feb-81	Jun-81	4	13%	0.03	-0.64	-0.16	-2.97	-0.74	0.68	0.17	1.41	0.35	-0.02	0.00	1.30	0.33
Jul-83	Aug-84	13	-2%	0.00	-0.04	0.00	0.31	0.02	1.36	0.10	0.67	0.05	0.50	0.04	0.71	0.05
Mar-88	Mar-89	12	3%	0.00	1.25	0.10	-1.70	-0.14	-0.50	-0.04	0.57	0.05	0.05	0.00	0.44	0.04
Feb-94	Apr-95	14	-7%	-0.01	1.36	0.10	-4.79	-0.34	0.15	0.01	0.17	0.01	0.27	0.02	0.20	0.01
May-99	Jul-00	14	-17%	-0.01	0.69	0.05	-3.44	-0.25	-0.39	-0.03	0.28	0.02	0.29	0.02	0.27	0.02
Apr-04	Jul-06	27	1%	0.00	-0.85	-0.03	0.99	0.04	-0.07	0.00	0.11	0.00	0.17	0.01	0.13	0.00
Dec-16	Feb-19	26	-13%	0.00	1.51	0.06	2.71	0.10	0.78	0.03	-0.15	-0.01	-0.07	0.00	-0.09	0.00
Jan-22		15	-24%	-0.02	-6.38	-0.43	-0.98	-0.07	0.89	0.06	0.37	0.02	0.24	0.02	0.37	0.02

Source: Refinitiv and Bloomberg

would expect the tightening to ease global price pressures. Of course, other factors affect these price-based measures, including the normalisation in energy markets after the sharp increase in prices, and the easing of supply-bottlenecks following long periods of lockdown. These price-based measures are displayed in Figure 39. The Baltic Dry Index (an indicator of freight prices) has eased significantly since the Covid peaks. All three categories of commodity prices - energy, food, industrial prices- have eased substantially, although news of the lifting of China's zero Covid policy around the turn of the year 2022/23 caused a modest lift. Short-term inflation swaps show a substantial decline since the peaks observed in 2022, although they are slightly higher than their pre-pandemic levels. The Cleveland Fed 1-year inflation expectations has also cooled materially. The dominant colour on these metrics leans towards cool blue, signaling a reduction in inflationary pressures. While we cannot attribute the easing in price measures to the financial tightening, given that there are so many factors behind it, these measures suggest a significant easing in global inflationary pressures.

We conclude this discussion with the "dot plot"[3], comparing the median forecast from the Fed's Economic Projections with market expectations (Figure 40). Market expectations are now firmly pricing in rate cuts already this year.

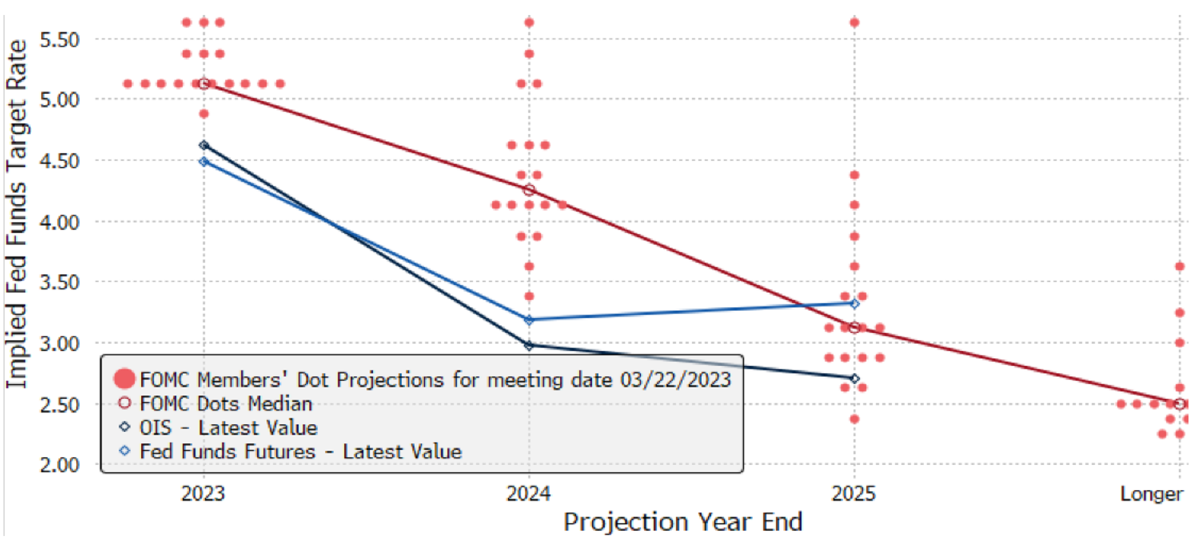
[3]The Fed's summary projections include a chart plotting each FOMC's participants' assessment of the appropriate monetary policy over the upcoming years and in the longer-run. This chart is commonly referred to as the "dot plot".

Figure 39: Selected indicators of price pressures

Start	End	Duration	Oil (Brent)		US Fed Trade Weighted Real Broad Dollar Index		Commodity Research Bureau BLS/US Spot Raw Industrials		Commodity Research Bureau BLS/US Spot Foodstuff		BDI Baltic Exchange Dry Index		Cleveland Fed Expected Inflation 1 Yr	
		in months	Total change, %	Average change per month	Total change, %	Average change per month	Total change, %	Average change per month	Total change, %	Average change per month	Total change, %	Average change per month	Total change in basis points	Average change per month
Dec-65	Nov-66	11	0.0%	0.0%			-10.6%	-1.0%	-0.4%	0.0%				
Dec-68	Aug-69	8	0.0%	0.0%			14.7%	1.8%	8.5%	1.1%				
Apr-71	Aug-71	4	32.0%	8.0%			-1.9%	-0.5%	1.7%	0.4%				
Feb-72	Sep-73	19	34.7%	1.8%			59.4%	3.1%	92.2%	4.9%				
Mar-74	Jul-74	4	-16.6%	-4.1%	-1.5%	-0.4%	-0.5%	-0.1%	22.0%	5.5%				
Apr-77	Apr-80	37	164.7%	4.5%	-0.7%	0.0%	34.9%	0.9%	6.7%	0.2%				
Feb-81	Jun-81	4	-12.7%	-3.2%	6.0%	1.5%	-2.3%	-0.6%	-5.8%	-1.5%				
Jul-83	Aug-84	13	-8.0%	-0.6%	6.6%	0.5%	7.3%	0.6%	9.0%	0.7%			26.44	2.0
Mar-88	Mar-89	12	27.7%	2.3%	1.4%	0.1%	12.2%	1.0%	4.9%	0.4%	0.9%	0.1%	84.97	7.1
Feb-94	Apr-95	14	36.7%	2.6%	-5.7%	-0.4%	27.5%	2.0%	-3.1%	-0.2%	110.1%	7.9%	66.01	4.7
May-99	Jul-00	14	84.4%	6.0%	3.1%	0.2%	3.0%	0.2%	-10.8%	-0.8%	67.2%	4.8%	34.34	2.5
Apr-04	Jul-06	27	121.9%	4.5%	-3.4%	-0.1%	29.4%	1.1%	-11.1%	-0.4%	-17.0%	-0.6%	94.77	3.5
Dec-16	Feb-19	26	17.0%	0.7%	-3.4%	-0.1%	-1.2%	0.0%	-4.2%	-0.2%	-31.5%	-1.2%	-50.23	-1.9
Jan-22		15	0.1%	0.0%	8.3%	0.6%	-12.6%	-0.8%	6.6%	0.4%	-0.4%	0.0%	-16.85	-1.1

Source: Refinitiv and Bloomberg

Figure 40: FED Dot Plot



The chart shows that markets expect the Fed to reverse tightening sooner than Fed's FMCO members as expressed by the 'dot plot". This divergence could be reconciled if, for example, markets were currently pricing in some downside risks that are not encompassed by the FMCO's modal projections.

To summarise, in the US, various market indicators, including recession-risk and financial variables, point to a material tightening in financial conditions. Comparing with previous tightening cycles, the recession risk factor appears relatively large and financial measures have tightened. Price-based measures in turn have eased (pointing to decreased external inflationary pressures). The material tightening underway and the reduction in global price pressures might partly explain markets' expectations of an earlier easing of monetary policy in the US than what forecasted by the FOMC.

4.2 Anchoring of Inflation Expectations

This section turns to the question of inflation expectations: how anchored are they? Figure 41) show that short-term inflation expectations picked up quickly and sharply in response to spot inflation, but this was not the case for medium-term inflation expectations which remain stable. This section attempts a quantification of the extent of anchoring of expectations using both short term and medium-long term expectational variables.

Building on the CBO's framework for inflation expectations, we set inflation expectations as a function of past inflation and the central bank's inflation target (equation 7) as follows:

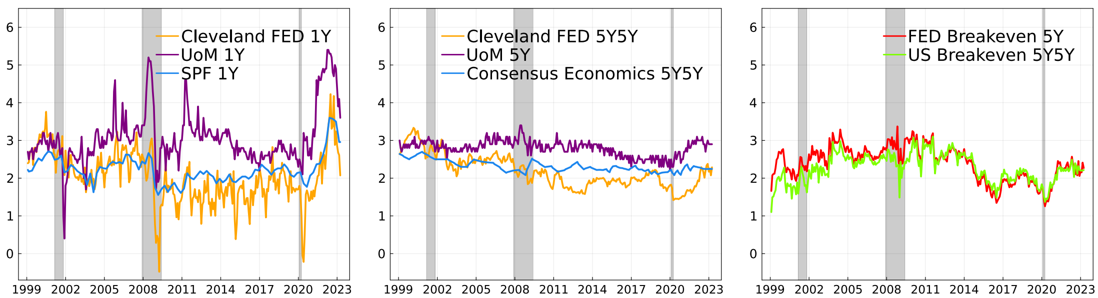
$$\text{Expected Inflation}_t = \sum_{i=1}^{p} \gamma_i \text{ PCE inflation}_{t-i} + \lambda \text{ Inflation Target} + \varepsilon_t \tag{7}$$

$$\text{where: } \sum_{i=1}^{p} \gamma_i + \lambda = 1; \quad \lambda \geq 0; \quad \sum_{i=1}^{p} \gamma_i \geq 0 \tag{8}$$

The model describes a situation in which, if inflation were to be determined solely by past inflation (i.e. λ with a value of zero), inflation expectations would behave in an "accelerationist" way, that is a 1% increase in actual past inflation with the given lags would result in a 1% increase in inflation. If, conversely, inflation expectations were guided solely by the central bank's inflation target, then these would be 100% anchored (i.e. λ with a value of one).

To fit the model, we use several measures of inflation expectations for the US: the University of Michigan survey of consumers; the Survey of Professional forecasters; the Consensus Economics survey of professional economists; the Cleveland Fed's inflation expectations (which are modelled derived)[4], market inflation break-evens and inflation swaps. These measures are plotted in Figure 41.

Figure 41: Different measures of Inflation Expectations



Source: Consensus Economics and Bloomberg

In the analysis, we look at the behaviour of the anchored term over both the near-term 1-year horizon and the medium (5Y5Y) horizon.[5] Our analysis starts in 1996. Setting a value on the inflation target is quite straightforward from 2012 onward, when the Fed adopted an explicit 2% inflation target. From 2007 onward, we can use the economic projections from the Board of Governors and the Presidents of the Federal Reserve Banks, published since then which also confirm a target close to 2%. As for the previous period, we follow Milani (2020) who shows that over the course of the late 1990s it became understood that the Fed had an unannounced inflation target somewhere around the 2% mark.

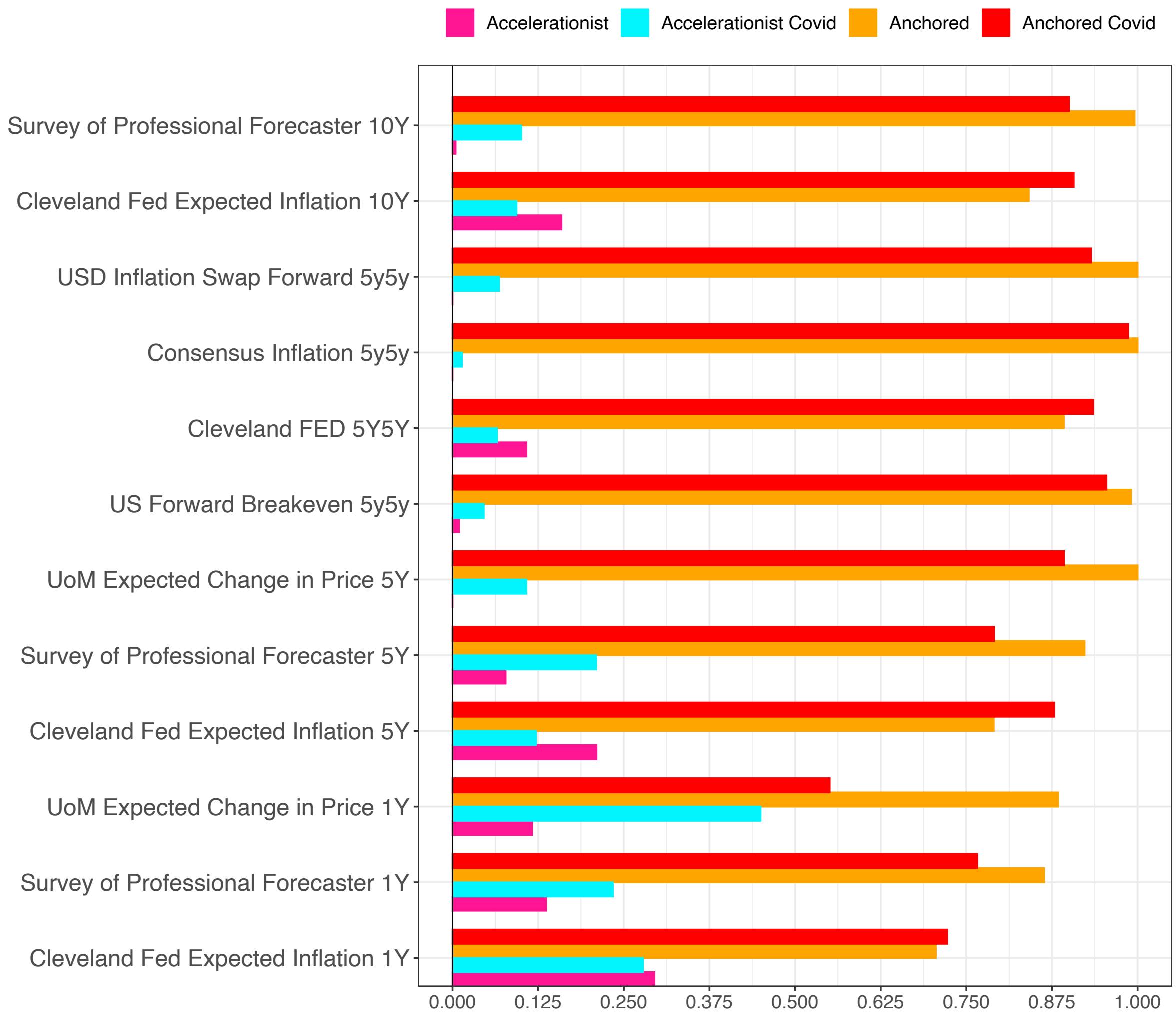
We draw on a gradient descent algorithm to estimate the model in equation 7 and further require the values hereof to be null or positive. Further details on the parameter estimates and their statistical properties are given in the appendix. We first estimate the equations for the various inflation surveys over the period 2000 to 2019, and then test with the more recent period starting in 2020 until the present, to which we refer as the Covid period in the figures. Results are reported in Figure 42.

We observe a slight decline in the anchored term across most of the survey measures between the pre-Covid period 2000-2019 and the Covid period 2020-2023. The exception is one year ahead University of Michigan consumer-based survey, which sees a more notable decline.

To understand the behaviour of the anchor term over time, we next estimate the equations over a seven-year rolling window. Results are illustrated in figure 43 (in the vertical axis we have the parameter values). They show that the anchored term is not constant but that changes in parameters are small for the 5y5y expectation of the Cleveland Fed and consensus (the anchored term is never below 75%),

[4]see Haubrich et al, 2011.
[5]Note that throughout the analysis, we use 5Y5Y and 6-to-10 year interchangeably.

Figure 42: Inflation Expectation Decomposition

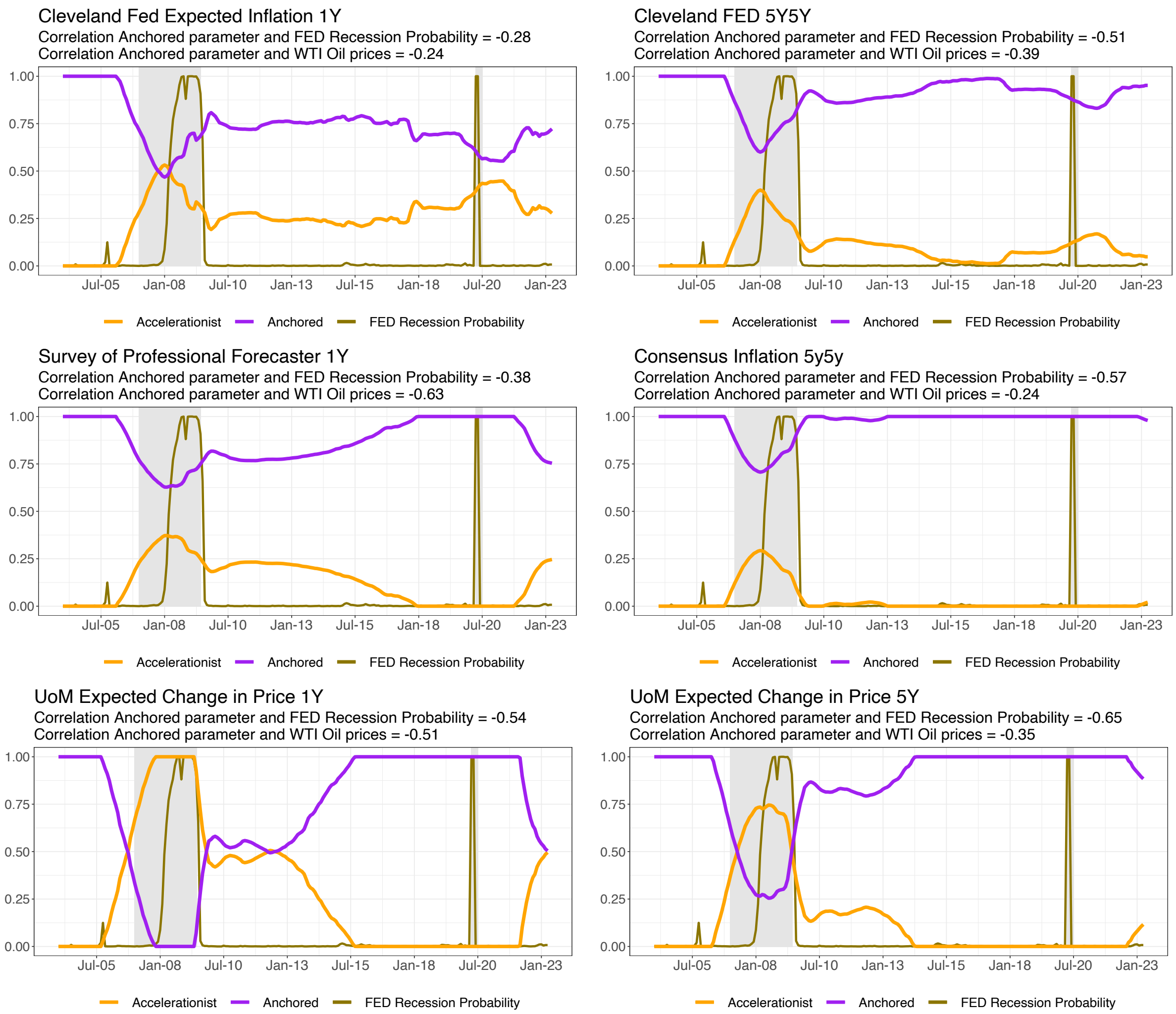


Source: Consensus Economics and Bloomberg

confirming the well known fact that short term expectations are volatile and so are consumer expectations in general.

The chart also reports the correlation between the anchor term and Fed recession probabilities and oil prices. The anchored term is negatively correlated with the Fed recession probability: as the probability of recession increases, the accelerationist term goes up while the anchored term declines. However, the average correlation is driven mostly by the Global Financial Crisis episodes. Over the Covid period it is virtually zero. The finding that recessions are a risk to the anchored component of inflation expectations suggests that a deep recession, if it occurred, may erode the credibility premium. This risk seems to have been larger during the Global Financial Crisis than it is today.

Figure 43: Rolling Window estimation

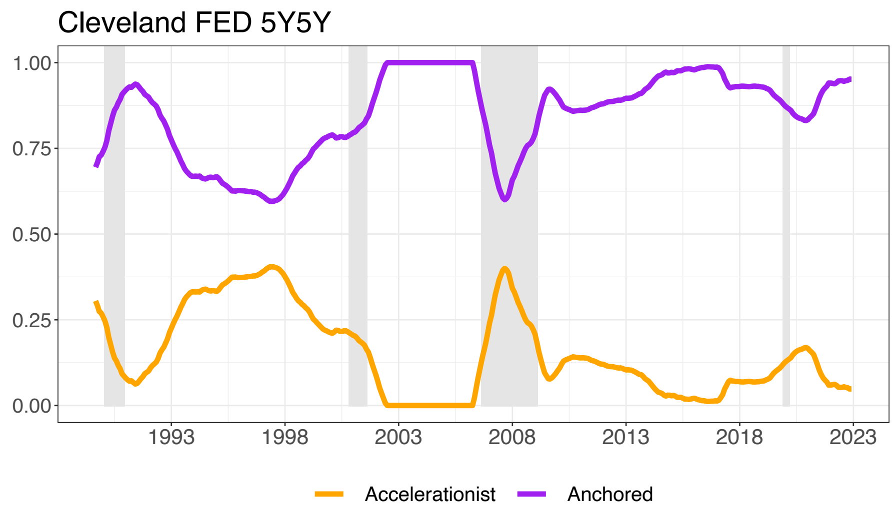


The correlation with oil prices is smaller. It increased in 2008 when oil prices surged, and it spiked up again, though very briefly, in the early phase of the pandemic, when oil prices fell. This suggests that the anchored component may be temporarily affected by oil prices but that volatility unwinds quickly as the shock dissipates.

As a final exercise we perform the rolling window exercise using Cleveland Fed data 5Y5Y since 1982. In an admittedly somewhat arbitrary way, we set the target from 1982 to 1996 at 4% and keep the 2% target since then. Results in Figure 44 show that the anchored term before the new millennium was much lower even if the model includes a higher inflation target. This result is not surprising and indicates that the Fed enjoys a higher credibility premium than in the past.

To summarise, while the recent inflation period has seen a slight decline in the anchored term, the

Figure 44: Rolling window estimation - 1982:2023



Source: Bloomberg

modest magnitude suggests central banks enjoy a firm credibility premium.

4.3 Anatomy of bonds yield

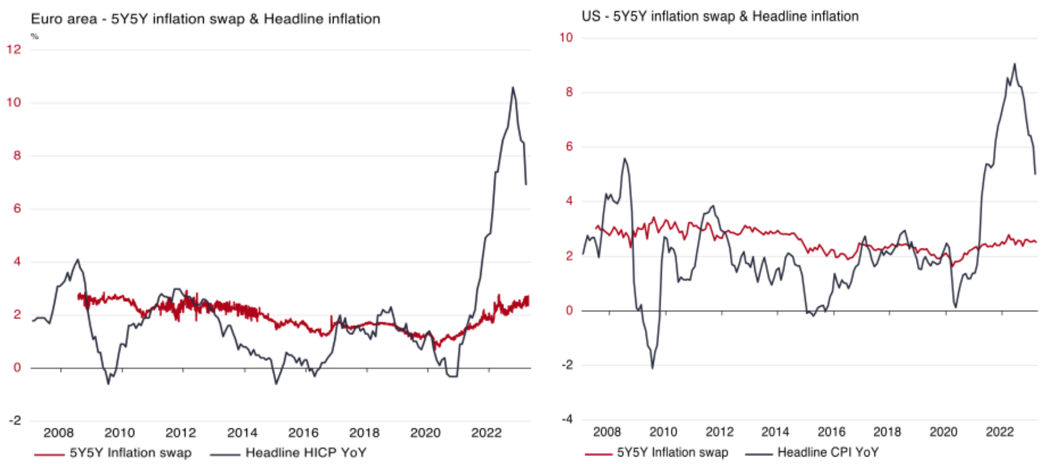
To complement the previous exercises, this section turns to the information on inflation expectations implied by bond yields. Inflation swaps for the five-year period that begins in five years from today (5Y5Y) are a common indicator of market inflation expectations and the related inflation term premium[6]. As illustrated by Figure 45, these have only risen modestly above 2%, during a period of material increase in headline inflation both in the EA and the US economy. The question is whether the slight increase in these indicators reflects a change in inflation expectations or rather the inflation risk premium component. To analyze it we use a simple decomposition of bond yields.

Risk-free bond yields can analytically be decomposed into three main components: (1) inflation expectations, (2) real short term rate expectations and (3) a term premium, which can be further broken down into an inflation term premium and a real term premium.

This decomposition is not directly observable. Estimates draw on two main methods. One method consists of obtaining the expectation component from surveys, leaving the term premium as the residual of market priced bond yields. Another method consists of combining the spot yield curve with a no-arbitrage condition, drawing on yield curve factors to derive a risk neutral yield (capturing the two expectation components) and a term premium. Some methods combine elements of both, and may further include

[6]Note, for ease simplicity, we refer both to the five-year period that begins in five years from today on market interest rates and the 6 to 10 year horizon of the long-term consensus as "5Y5Y".

Figure 45: US and EA Inflation-linked SWAP 5Y5Y



Source: Bloomberg

various market or macro variables.

The survey-based methods have the advantage of being easy to replicate; moreover, individual components can be readily discussed and challenged. The drawbacks come from infrequent updates and the risk that these may not accurately reflect market expectations or carry biases. The yield curve-based methods, on the other hand, may be prone to overreaction.

Our analysis uses a survey-based method, drawing on the 6-to-10 year outlook from the survey conducted by Consensus Economics. We start from the 5Y5Y nominal market bond yield, and subtract (1) an inflation expectations component, set equal to the 6 to 10-year consensus inflation expectations and (2) a real 3-month interest rate, set equal to the 6 to 10-year consensus nominal 3-month interest rate expectation minus the prior inflation expectation component. This residual is the nominal term premium. We have:

$$\text{Bond yield} - \text{Consensus inflation} - \text{Consensus real yield} = \text{Nominal term premium} \tag{9}$$

The 6-to-10-year consensus expectations come from Consensus Economics. This long-term survey is updated on a quarterly basis since 2014 and semi-annually since 1990. To build, respectively, a monthly and a weekly time series, we draw on simple linear interpolation. Overall, modest changes between individual survey dates suggest that these medium-term expectations are less at risk of suffering from the drawback of infrequent updates. A further advantage is that at the 6-to-10-year horizon, the survey likely captures views on trend values. The latest point for the consensus is April 2023.

To find the inflation term premium, we subtract the consensus inflation expectations from market break-even. We are mindful that market break-evens, derived from inflation linked bonds, may suffer from issues in terms of market depth and the specific needs of investors present in this segment. Inflation linked swaps can help over come some of these issues, but have a shorter history, dating back only to 2004, compared to 1999 for the break-evens.

$$\text{Market inflation breakevens} - \text{Consensus inflation} = \text{Inflation term premium} \tag{10}$$

Finally, we find the real term premium by subtracting the inflation term premium from the nominal term premium.

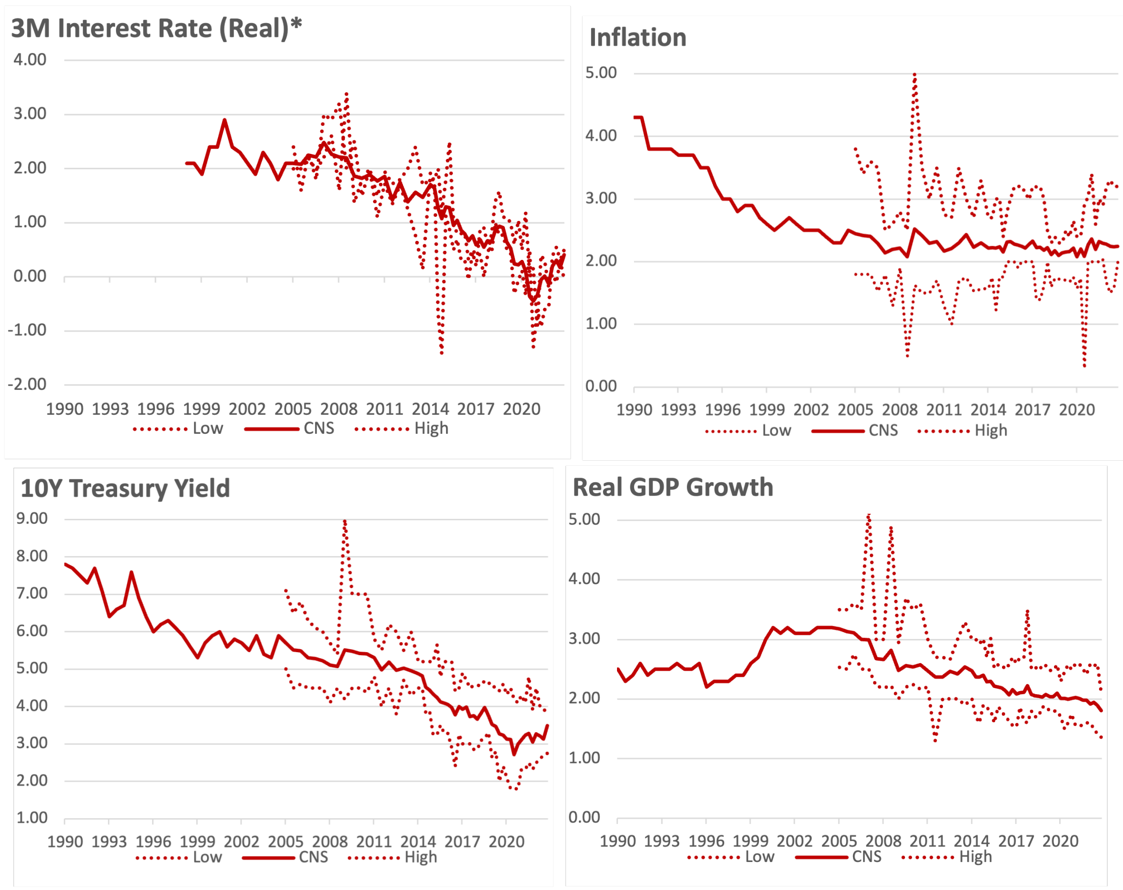
$$\text{Nominal term premium} - \text{Inflation Term Premium} = \text{Real term premium} \tag{11}$$

To implement these decompositions we use consensus data on the relevant variables. We first examine market expectations on interest rates and real economic activity. Figure 46 reports consensus Economic survey data on nominal long-term interest rates, inflation, output growth and the market expectation on the 3 month real rate, 60 to 10 years from now. The real rate is constructed as the expectation on the nominal rate minus consensus inflation expectations. The term consensus is used here to refer to the median estimate of the survey sample. Since the expectations series has a long term horizon, the real rate could be interpreted as the market view of the natural rate of interest and, for short, we have described it with a star. Of course this interpretation can be challenged.

The chart shows that inflation expectations for the US have remained remarkably stable and close to the 2% inflation target. Looking at the survey high and low bounds, we note a shift up, but this is not outside the ranges observed during the preceding period, when actual headline inflation was around the target. On the 3-month real interest rate, we observe a slight upward move, essentially returning the variable to pre-pandemic levels.

Turning to the long-term consensus for the Euro area in figure 47, we observe similar trends to those observed for the US, albeit with a shorter data history. The consensus for euro area inflation has moved marginally higher since the 1.8% low of October 2020 but remains very close to 2%, with the latest reading at 2.04%. As we observed for the US, the consensus on the real short-term rate has recovered from the fall during the pandemic and is now close to early 2019 levels. A similar movement is observed on the Bund yield. Finally, we note that the long-term consensus for euro area real GDP growth has been fairly stable, albeit marginally down from pre-pandemic levels.

Figure 46: US Long-Term Consensus (6-10 years)



Source: Consensus Economics

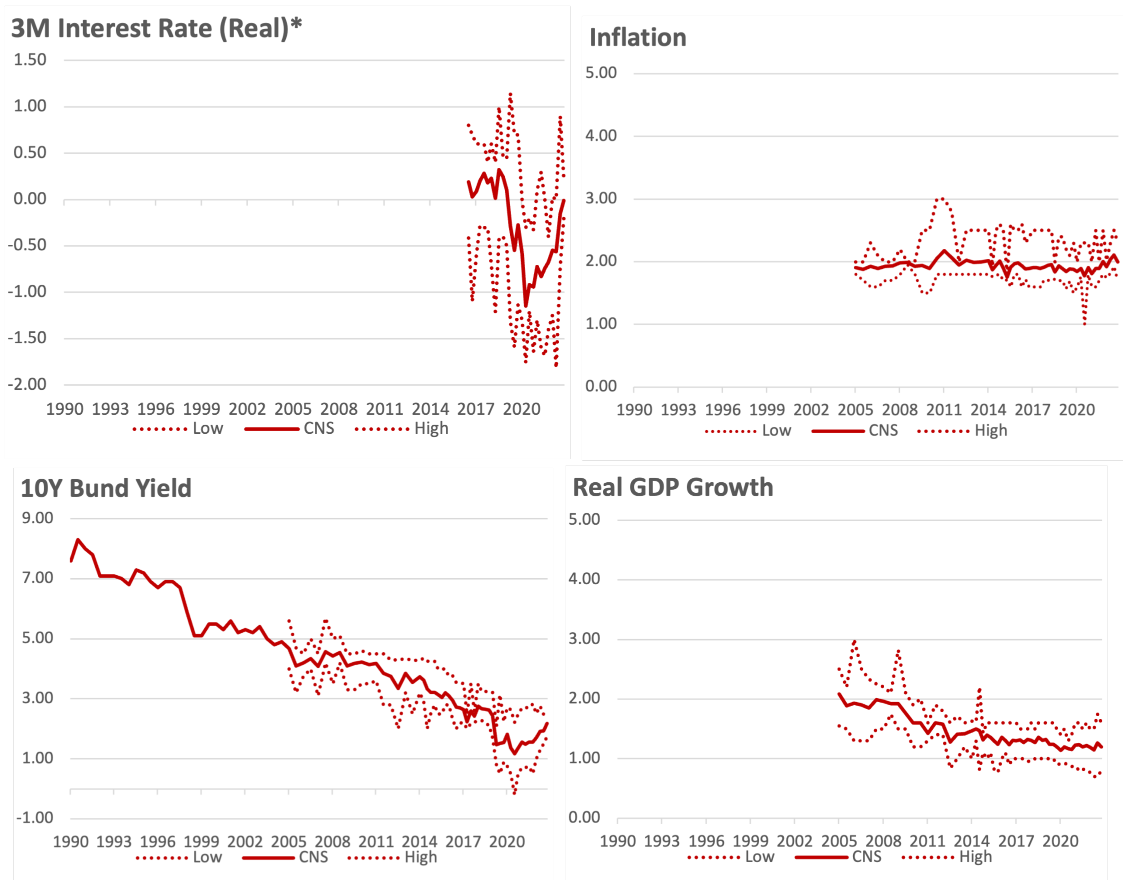
We next use the bond yield decomposition to derive inflation term premia and real term premia. Figure 48 reports the premia plotted against consensus inflation and real short rate five year from now.

The chart shows that term premia are historically volatile and, as shown previously, that the real term premium has been increasing slightly at the end of the sample, although the movement is not unusual when compared with the historical evidence. The inflation term premium, on the other hand, is stable.

In order to better understand risk premia, we examine correlations with a variety of observed indicators. If our breakdown is meaningful, we should observe that the inflation term premium increases when risks to price stability increase, while the real term premium should increase when the uncertainty on the future path of real rate increases.

Table 3 shows the correlation of each data series (columns) with the derived, real, inflation and total term premia. The first two columns show the correlation with, respectively, the premia estimated by Adrian, Crump and Moench, 2008 (ACM) and KW by those estimated by Kim and Wright, 2005 (KW).

Figure 47: EA Long-Term Consensus (6-10 years)



Source: Consensus Economics

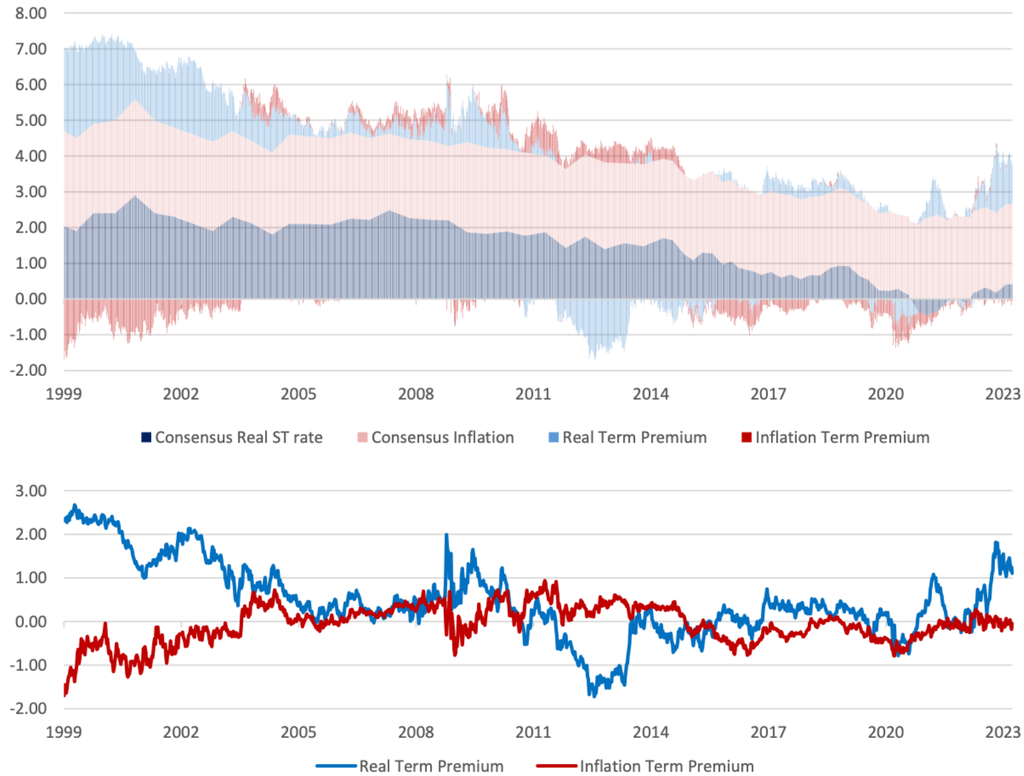
We then have WTI 1st contact[7], the trade weighted nominal US dollar exchange rate , an indicator of the yield curve, the federal fund rate and the difference between the actual federal fund rate and the shadow rate (as computed by Wu Xia (citation needed here)) and the Merrill Lynch Option Volatility Expectations (MOVE)[8]. The difference between the federal funds rate and the shadow rate can be seen as a simple proxy to capture the impact of the policy tools used at the zero lower bound such as QE and forward guidance. When the difference increases, this is taken as an indication that the monetary policy stance is becoming more accommodative, compressing the real term premium.

Turning first to the correlations with the inflation premium, the following observations stand out. Commodity prices are highly positively correlated with the inflation premium component rather than with the actual medium-term inflation expectations, in line with the literature (cite). This indicates that high short-term oil prices add to the risk of higher inflation over the medium term, without affecting

[7]This is a monthly cash settled mini future based on the daily settlement price for the NYMEX WTI Crude Futures

[8]This is a yield-curve weighted measure index of normalised implied 1-month volatility on Treasury options on the 2, 5, 10 and 30 year contracts

Figure 48: US 5Y5Y Yield



Source: Consensus Economics and Bloomberg

Table 3: Correlation of Consensus Derived Term Premia (Weekly, Jan-2019 to latest).

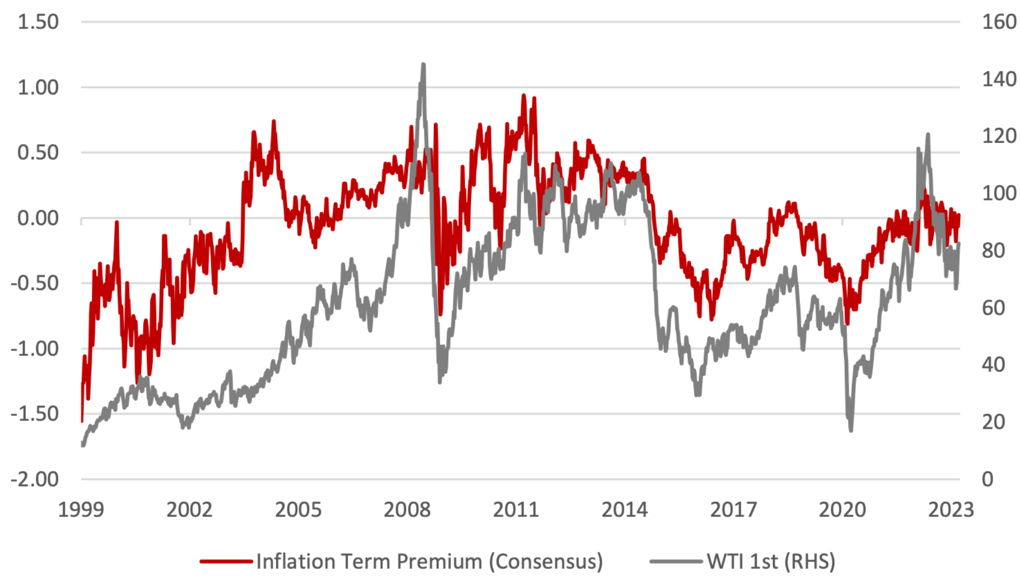
	ACM Term Premia	KW Term Premium	WTI 1^{st} Contract	US FED Trade Weighted Nominal	Yield Curve 10Y-2Y	Fed Funds	MOVE	BofA Global Financial Systemic Risk Indicator	FED funds Shadow Rate
Real premia	-	-	-56%	27%	-2%	51%	53%	44%	-47%
Inflation premia	-	-	71%	-66%	48%	-35%	2%	-14%	38%
Total risk premia	74%	86%	-25%	4%	21%	37%	58%	39%	-33%

inflation expectations. Figure 49 shows the high correlation between oil prices and the inflation risk premium since 2008.

The trade-weighted dollar likewise yields the expected coefficient signs, with a stronger dollar detracting from inflation risks in the US. The yield curve slope links positively to the inflation components, while a higher Fed funds rate dampens the inflation premia. The correlation with the difference federal fund rate-shadow rate has the expected positive sign. The final two variables, which reflect financial risks, show no clear link to the inflation premium. As financial condition indices in the period covered were generally not linked to inflation, this observation is not surprising.

Turning to the real term premium, we observe a positive correlation with the Fed fund rate and

Figure 49: US Inflation Term Premium 5Y5Y and WTI 1st



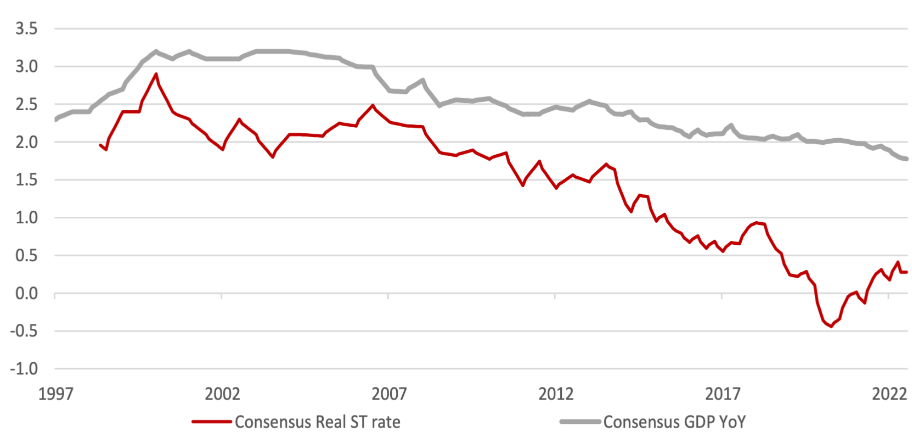
Source: Consensus Economics and Bloomberg

measures of market risks, negative with the shadow rate as expected. The correlation with the oil prices is harder to interpret. It could be understood as oil prices signaling higher risks for the real economy.

Finally, we note that our estimate of the total term premia is highly correlated with that of Kim and Wright (KM). This is not surprising since both are survey-based methods. In the appendix we report the historical data for the three estimates. As a whole, the correlations indicate that the estimates of the risk premia behave in line with reasonable priors.

To shed some more light on the real rate, we turn our focus on Figure 50, which plots the consensus view on the real short term rate against consensus GDP year-on-year rate of growth.

Figure 50: US - Long Term Consensus (6-10Y) GDP growth and real short term rate



Source: Consensus Economics

The chart shows the historical positive gap between the rate of growth and the real rate (see Blanchard ??? and citations therein) and the increasing gap since the Global Financial Crisis. This has been interpreted by the literature as an increasing safety premium (see Reis and citations therein). Notice that this has further increased during the pandemic and is now returning to the historical trend. Although this is thin evidence to draw firm conclusions, we conjecture that the increase in the real interest rate at the end of the sample does not reflect a change in the natural rate but just a normalization after the fall during the pandemic.

Under this interpretation it is reasonable to further conjecture that, once this correction is complete, the consensus on the natural rate will resume its structural downward trajectory. This hypothesis is in line with the last IMF's Global Financial Stability Report (April 2023) which suggests that the recent increase in real rates is likely to prove temporary. An alternative interpretation is that the upward movement on the consensus real rate reflects the market view that the Fed will have to keep rates higher than the pre-pandemic era to keep inflation at target. At this point it is hard to distinguish between these two interpretations or, indeed a third possibility that real rates will stabilise rather than either fall or rise.

To summarise, medium term inflation expectations are stable, while risk premia have increased slightly at the end of the sample. This increase is to be attributed to an increase in the real premium. The increase so far is in line with historical volatility, and does not indicate a visible trend (or change) with a clear interpretation.

Conclusions

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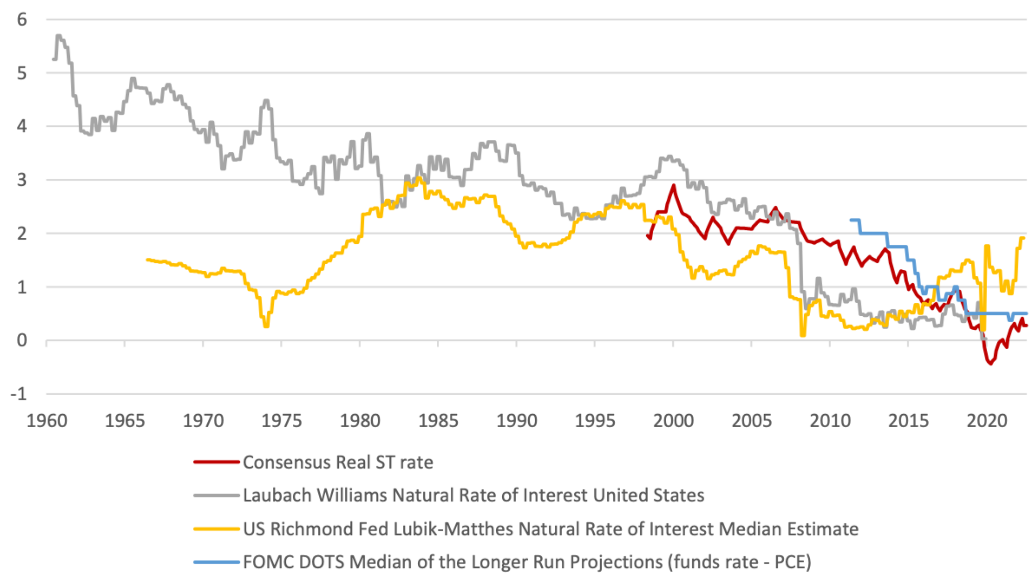
Appendix A

Table 4: Variables

Series	Source Name	Source	Transf.	Rel. Importance (If Applicable)
US				
Federal Funds Rate	Federal Funds Rate	FRED	Level	–
Spot Oil Price: WTI	Spot Oil Price: West Texas Intermediate	Haver Analytics	Level	–
Inflation Rate	CPI-U: All Items	Haver Analytics	YoY(%)	100
Core Inflation	CPI-U: All Items Less Food and Energy	Haver Analytics	YoY(%)	80.801
Food	CPI-U: Food at Home	Haver Analytics	YoY(%)	13.613
Tobacco and Smoking Products	CPI-U: Tobacco and Smoking Products	Haver Analytics	YoY(%)	0.608
Fuels	CPI-U: Fuels and Utilities	Haver Analytics	YoY(%)	4.38
Footwear	CPI-U: Footwear	Haver Analytics	YoY(%)	0.604
Household Furnishings	CPI-U: Household Furnishings and Operations	Haver Analytics	YoY(%)	4.682
Shelter	CPI-U: Shelter	Haver Analytics	YoY(%)	33.316
Medical Care Commodities	CPI-U: Medical Care Commodities	Haver Analytics	YoY(%)	1.508
Medical Care Services	CPI-U: Medical Care Services	Haver Analytics	YoY(%)	7.289
Men's and Boys' Apparel	CPI-U: Men's and Boys' Apparel	Haver Analytics	YoY(%)	0.666
Women's and Girls' Apparel	CPI-U: Women's and Girls' Apparel	Haver Analytics	YoY(%)	1.075
Photographic Equipment and Supplies	CPI-U: Photographic Equipment and Supplies	Haver Analytics	YoY(%)	0.071
Recreational Reading Materials	CPI-U: Recreational Reading Materials	Haver Analytics	YoY(%)	0.120
Public Transportation	CPI-U:Public Transportation	Haver Analytics	YoY(%)	1.105
Private Transportation	CPI-U: Private Transportation	Haver Analytics	YoY(%)	14.055
Housing	CPI-U: Housing	Haver Analytics	YoY(%)	42.385
Services	CPI-U: Services	Haver Analytics	YoY(%)	62.261
Durables	CPI-U: Durables	Haver Analytics	YoY(%)	10.942
Nondurables	CPI-U: Nondurables	Haver Analytics	YoY(%)	26.397
Commodities	CPI-U: Commodities	Haver Analytics	YoY(%)	37.339
Industrial Production	Industrial Production Index	Haver Analytics	log∗100	–
Capacity Utilization	Capacity Utilization: Industry	Haver Analytics	(%)	–
Unemployment rate	Civilian Unemployment Rate: 16 yr +	Haver Analytics	(%)	–
Personal Income	U.S.: Personal Income	Haver Analytics	YoY(%)	–
Personal Consumption Expenditure	Personal Consumption Expenditure	FRED	YoY(%)	–
EA				
Euribor 3-month	Euribor 3-month - Historical close, average	ECB	Level	–
Spot Oil Price: WTI	Spot Oil Price: West Texas Intermediate	Haver Analytics	Level	–
Inflation Rate	EA11-20: HICP: Monetary Union	Haver Analytics	YoY(%)	100
Core Inflation	EA11-20: HICP: Total ex Energy/Food/Alcohol/Tobacco	Haver Analytics	YoY(%)	69.790
Food and Nonalcoholic Beverages	EA11-20: HICP: Food and Nonalcoholic Beverages	Haver Analytics	YoY(%)	16.100
Alcoholic Beverages and Tobacco	EA11-20: HICP: Alcoholic Beverages and Tobacco	Haver Analytics	YoY(%)	3.800
Transport	EA11-20: HICP: Transport	Haver Analytics	YoY(%)	15.000
Housing, Water, Elect, Gas, Oth Fuels	EA11-20: HICP: Housing, Water, Elect, Gas, Oth Fuels	Haver Analytics	YoY(%)	15.200
Furnishings, HH Equip, Maintenance	EA11-20: HICP: Furnishings, HH Equip/Maintenance	Haver Analytics	YoY(%)	6.800
Health	EA11-20: HICP: Health	Haver Analytics	YoY(%)	4.900
Education	EA11-20: HICP: Education	Haver Analytics	YoY(%)	1.000
Recreation and Culture	EA11-20: HICP: Recreation and Culture	Haver Analytics	YoY(%)	8.900
Clothing and Footwear	EA11-20: HICP: Clothing and Footwear	Haver Analytics	YoY(%)	5.200
Communications	EA11-20: HICP: Communications	Haver Analytics	YoY(%)	2.700
Hotels Cafe and Restaurant	EA11-20: HICP: Hotels, Cafes and Restaurants	Haver Analytics	YoY(%)	10.500
Miscellaneous Goods and Services	EA11-20: HICP: Miscellaneous Goods and Services	Haver Analytics	YoY(%)	9.900

Appendix B

Figure 51: US - Different reconstructions of the natural rate of interest.



Source: Consensus Economics

Comparing the total term premium, we find to two popular methods from Adrian, Crump and Moench (ACM) and Kim and Wright (KW), we observed that our simple survey-based method yields results quite close to that of KW but also tracks the broader trends of the ACM approach. This is not surprising as the ACM is a yield curve-based approach, while the KW also combines survey elements. Presently, the consensus term premium is the only one to show a recent increase in the 5Y5Y premium ¡double check after April update¿.

Figure 52


5.00
4.00
3.00
2.00
1.00
0.00
-1.00
-2.00
1999
2002
2005
2008
2011
2014
2017
2020
2023
Consensus Term Premium
ACM Term Pemia
KW Term Premium